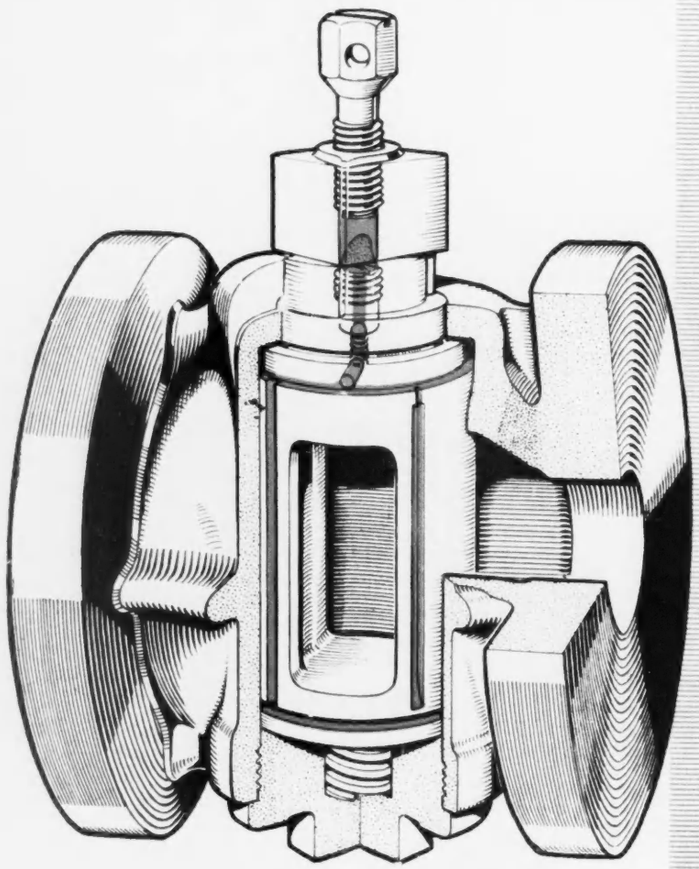
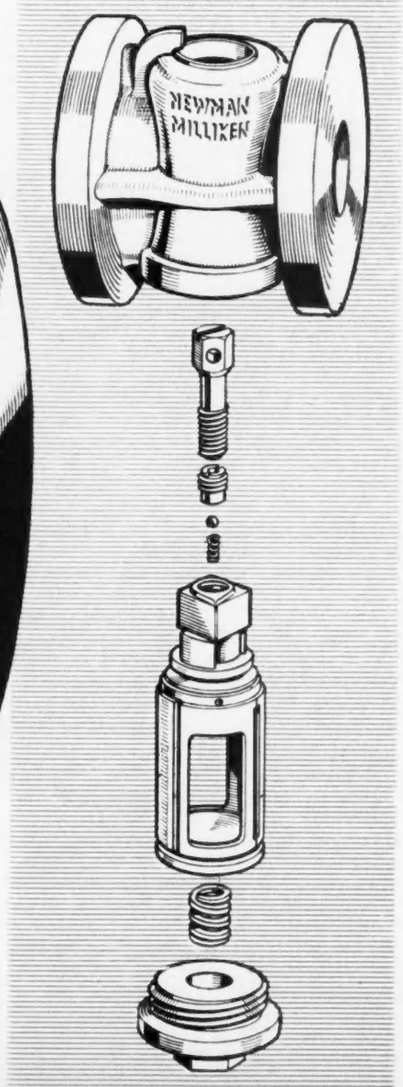
The Engineer

DECEMBER 12, 1958 28 ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS

Newman-Milliken

Glandless lubricated plug valves





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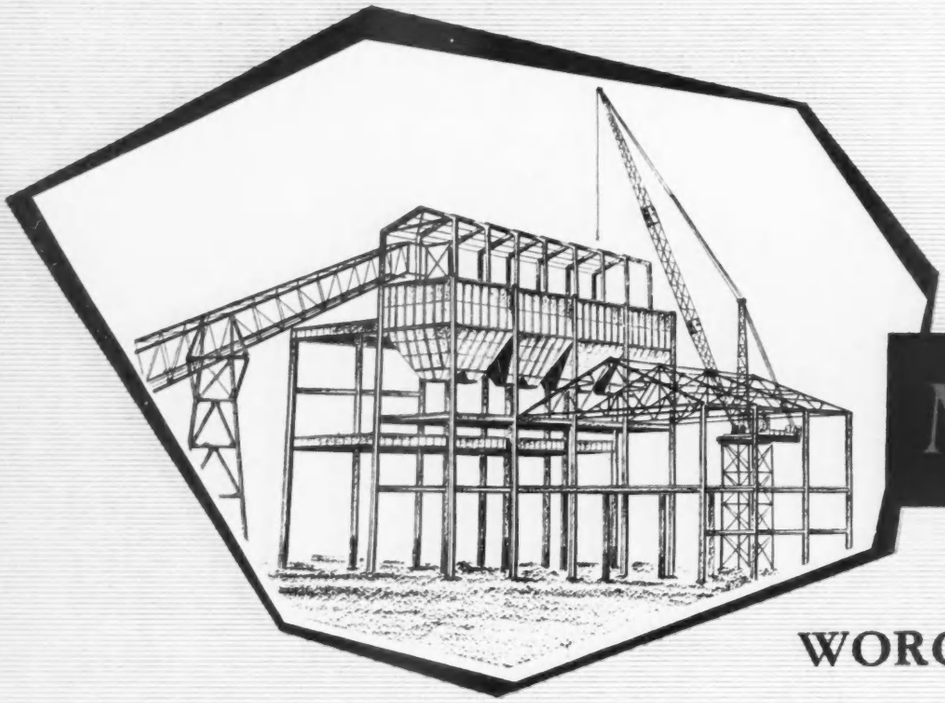

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Established 1856

No. 5368 **DECEMBER 12, 1958** VOL. 206

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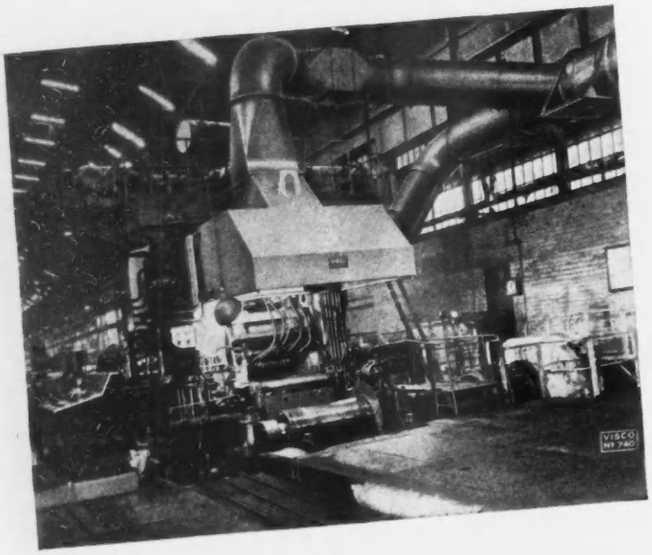
Photo by courtesy of Messrs. Richard Thomas & Baldwins Ltd.



fume removal for steelworks

Another " Visco " fume removal plant at a South Wales steelworks is illustrated above. This photograph shows a Robertson 4—high reversing mill equipped with " Visco " fume removal plant at the Panteg Works of Richard Thomas & Baldwins Ltd.

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The photograph shows the extract hood on the outgoing side of the mill.

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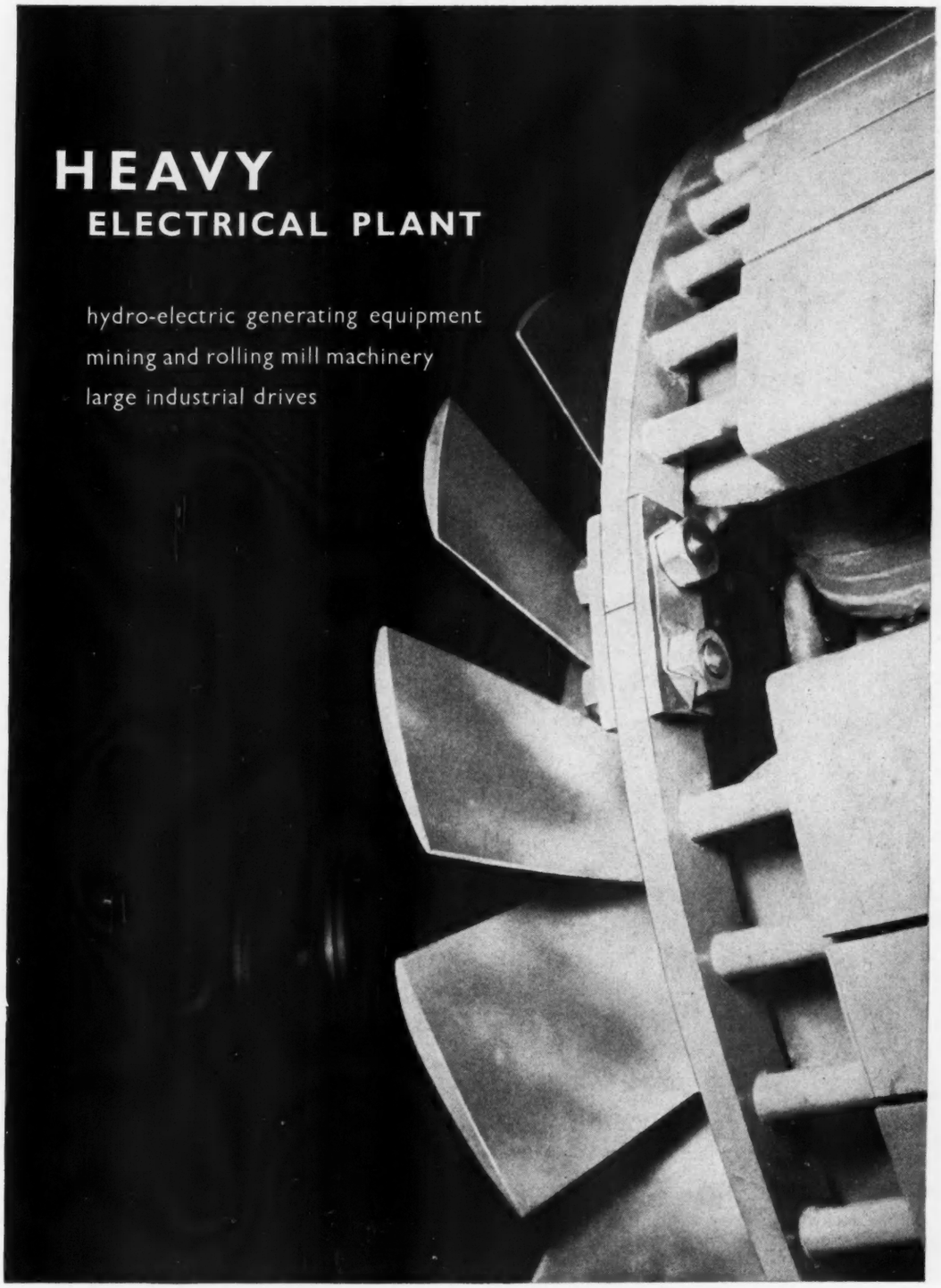

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before

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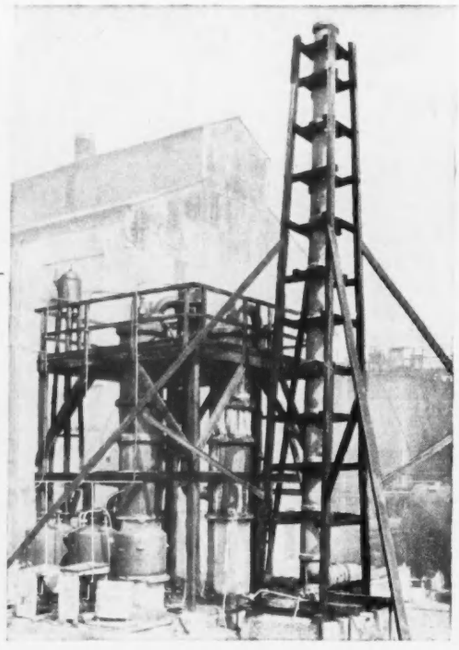

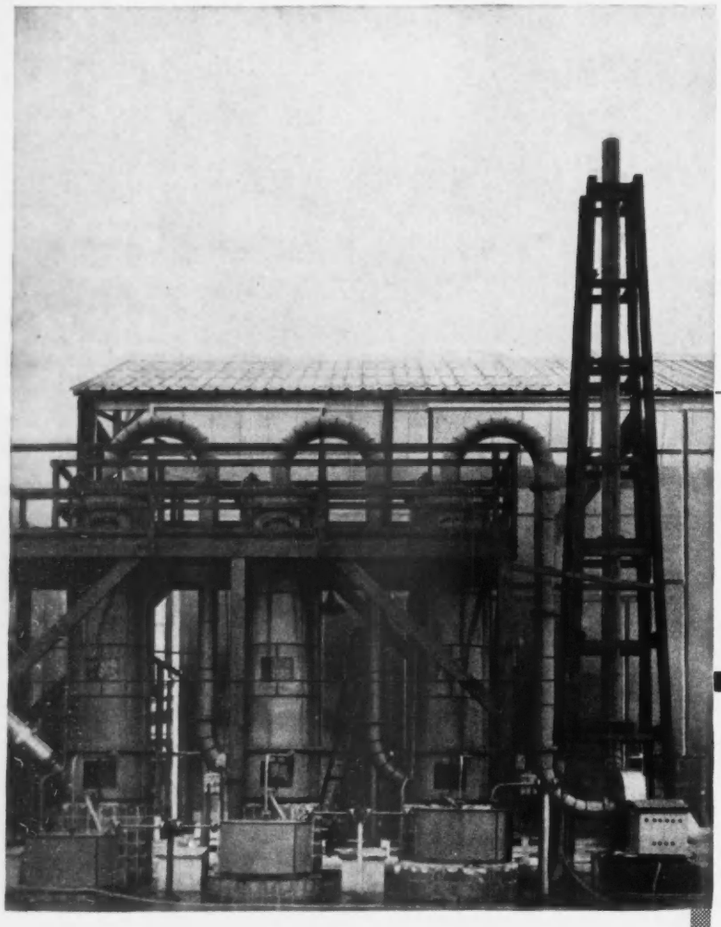

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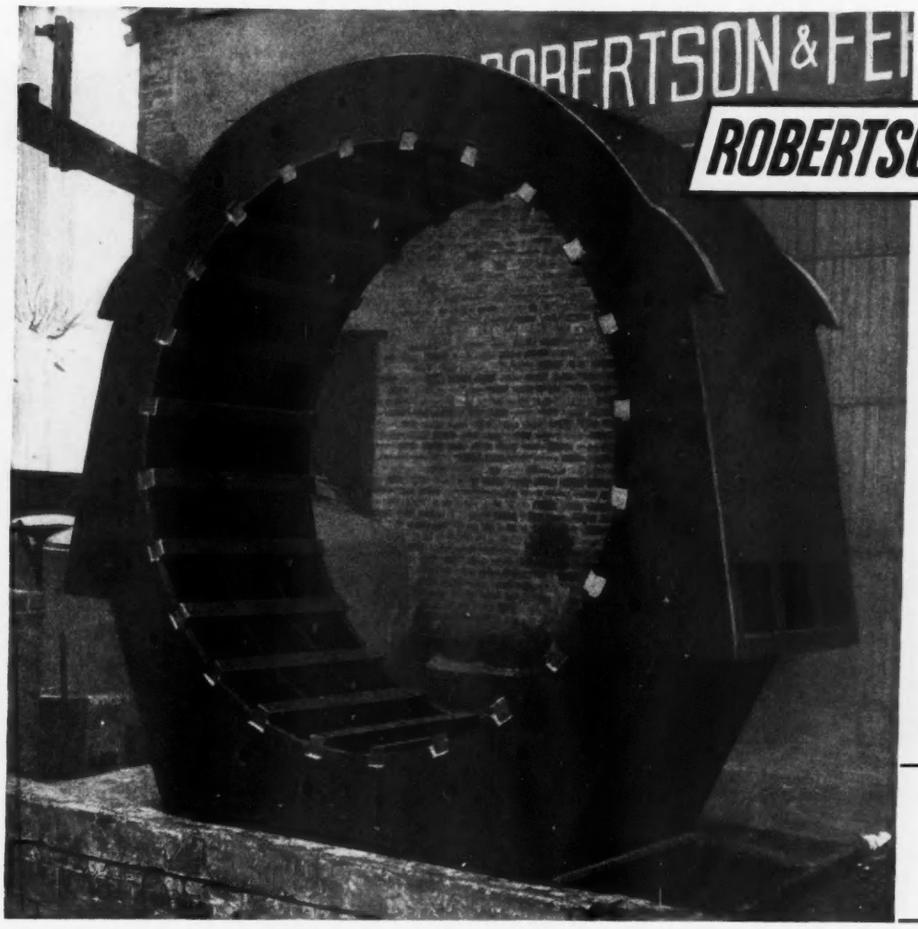

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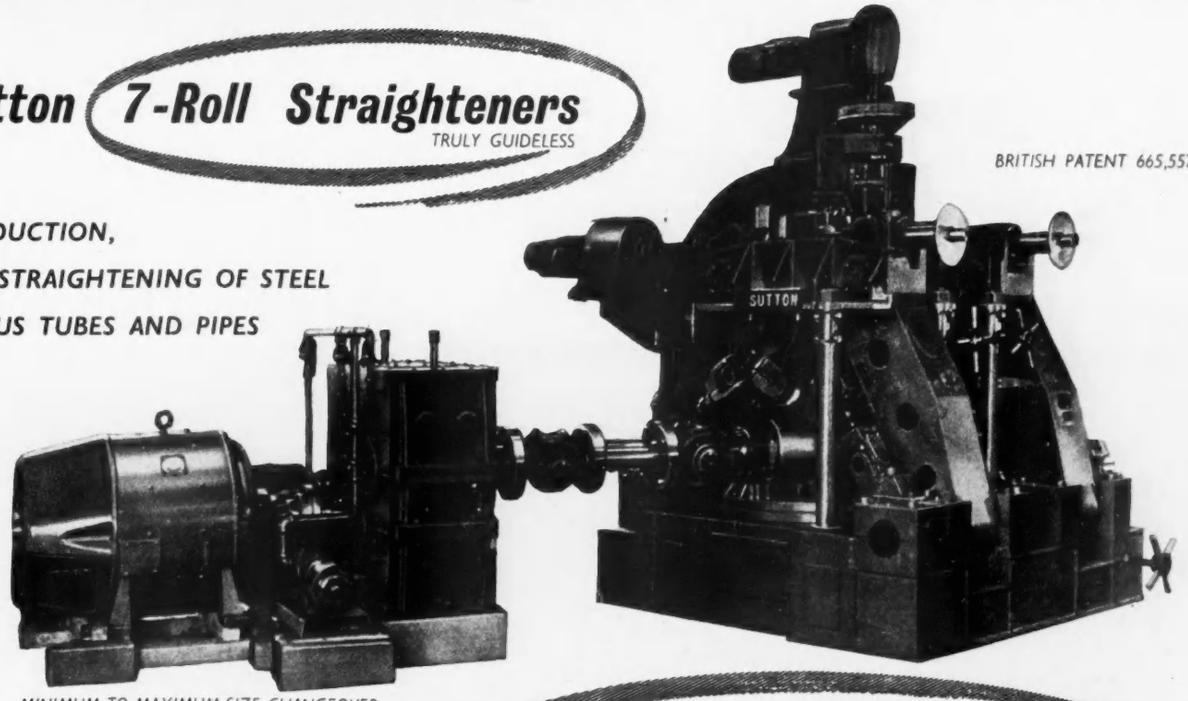

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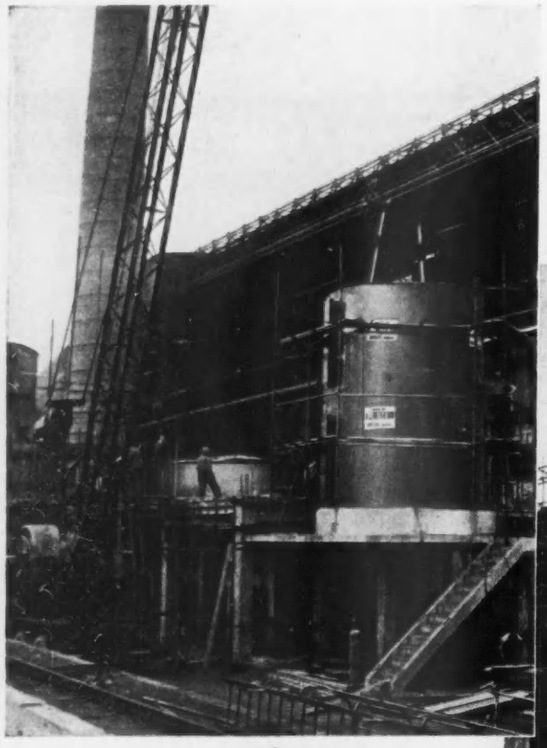

Left: Liquor cooler in course of erection, using 20 ton mobile crane.

Below: Site erection of Steel Silos at a Cement Factory.

SITE ERECTION BY

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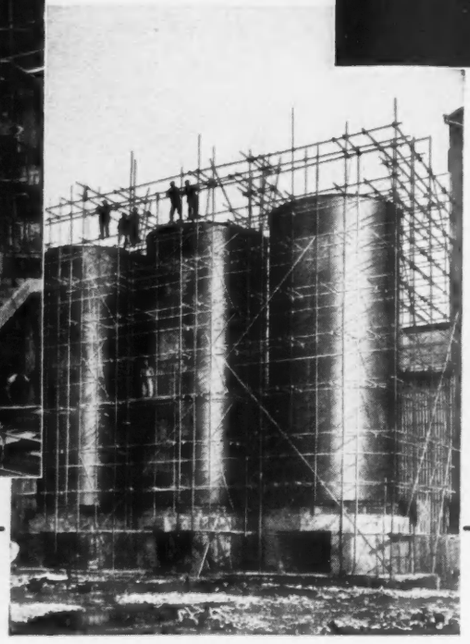

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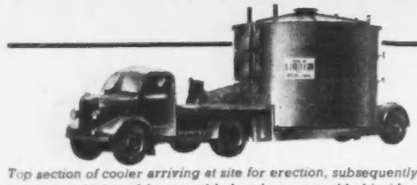

Top section of cooler arriving at site for erection, subsequently all circumferential joints of the assembled cooler were welded inside and out.

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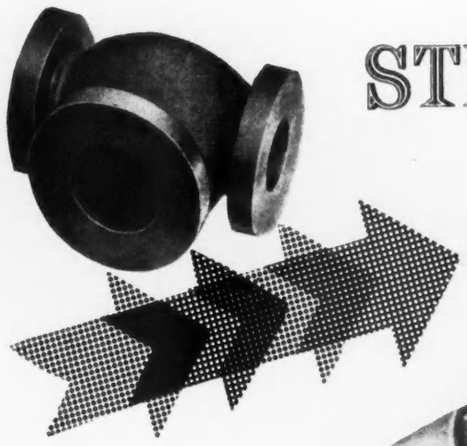
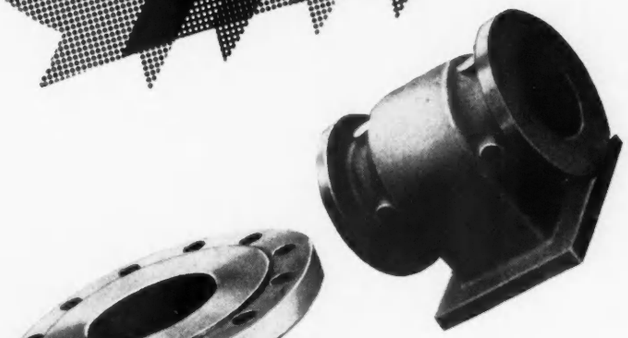


STEEL PRESSURE CASTINGS



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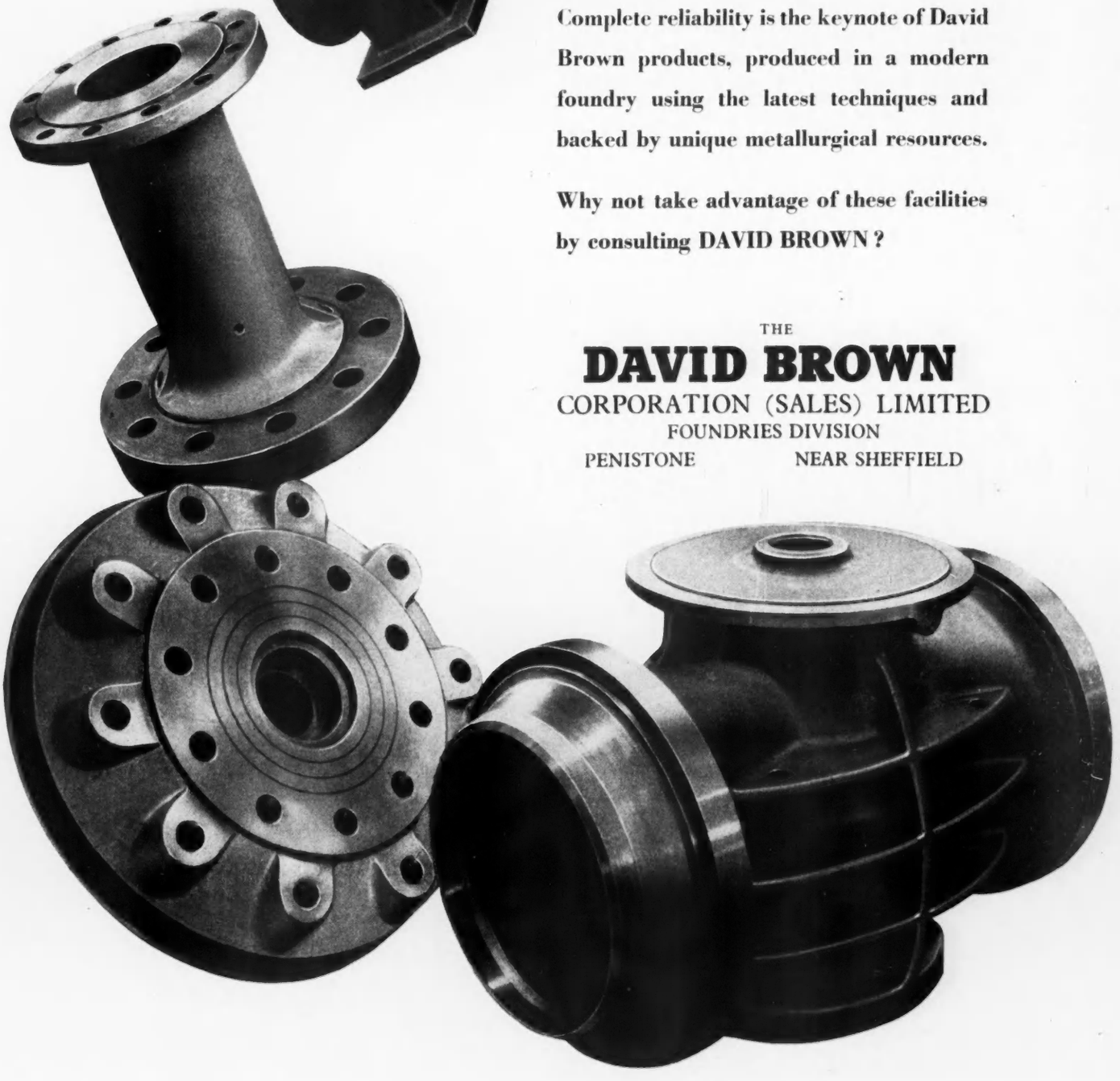

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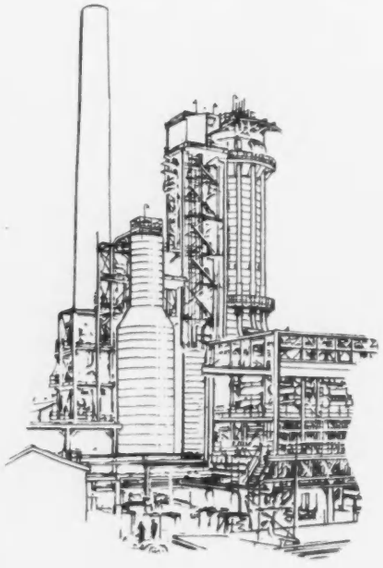

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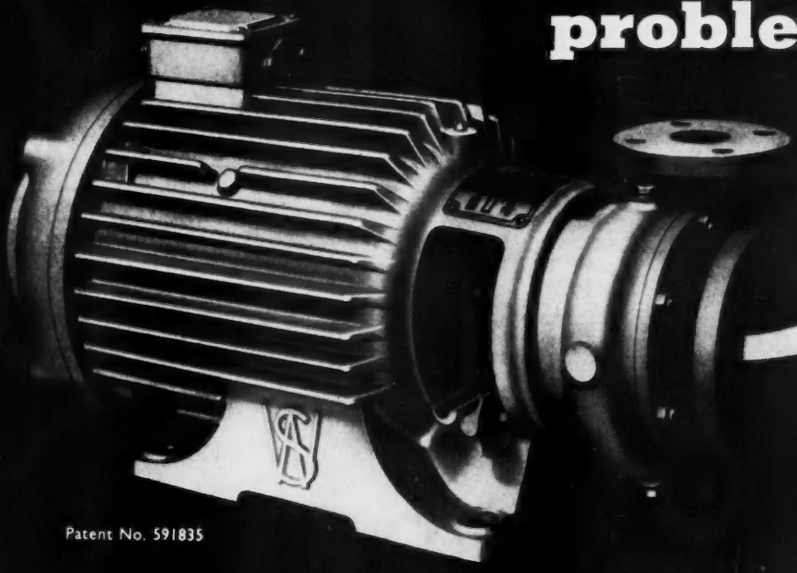

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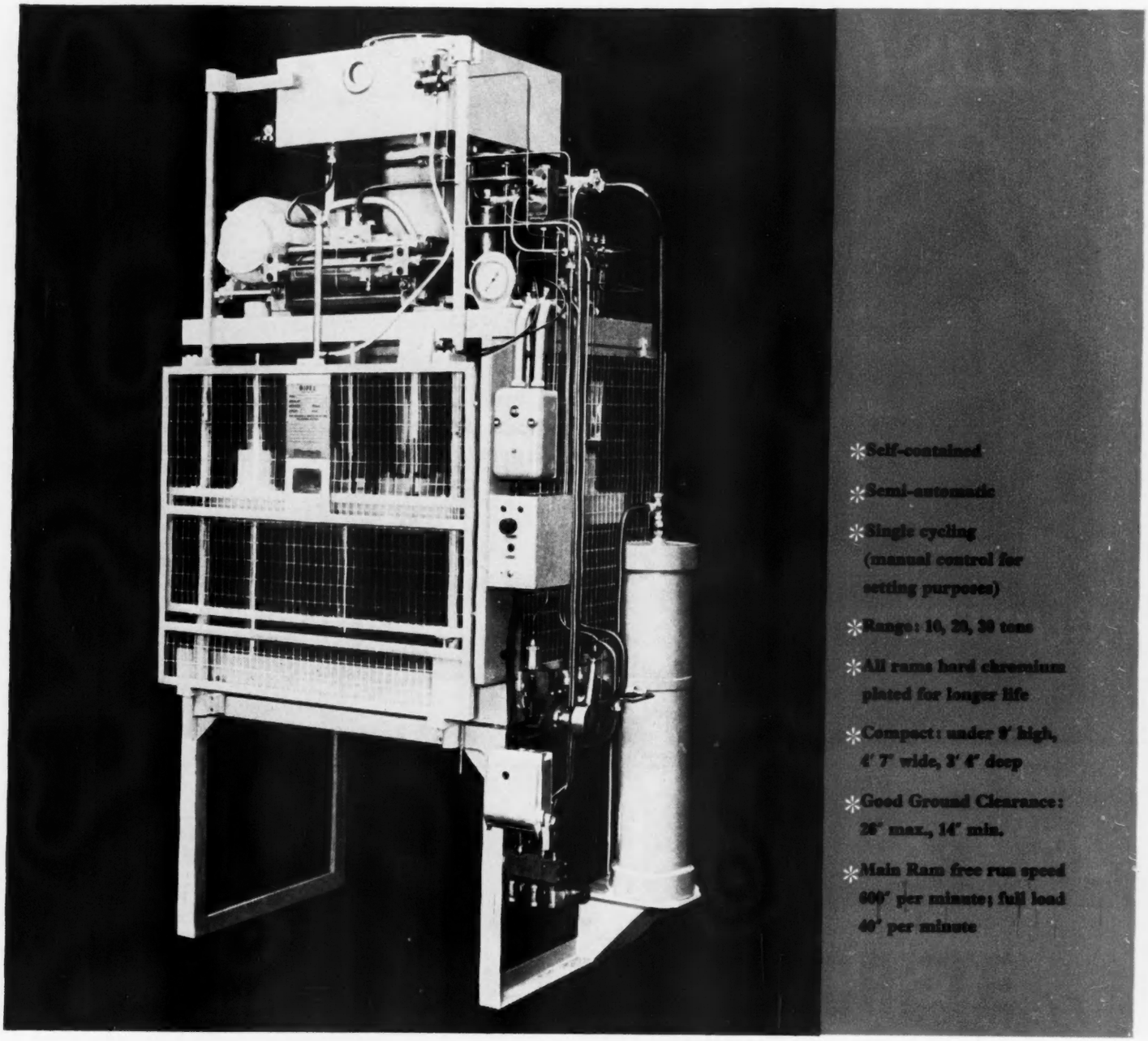

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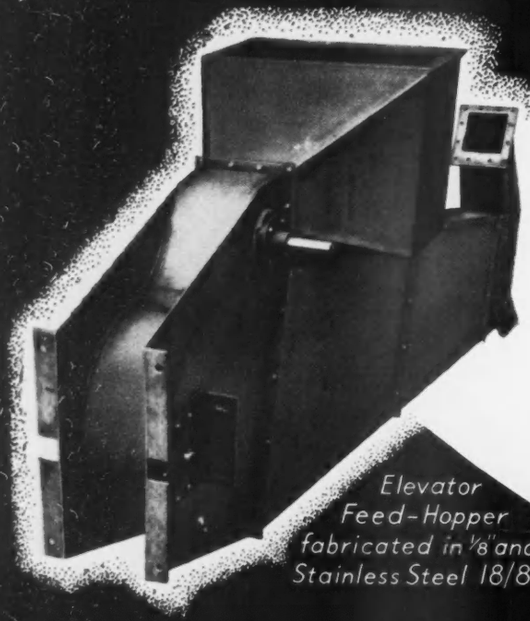

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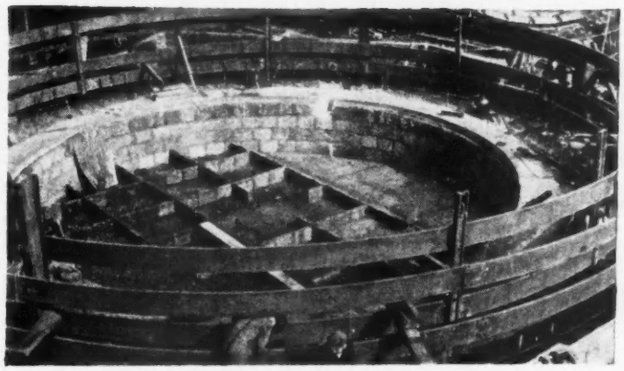

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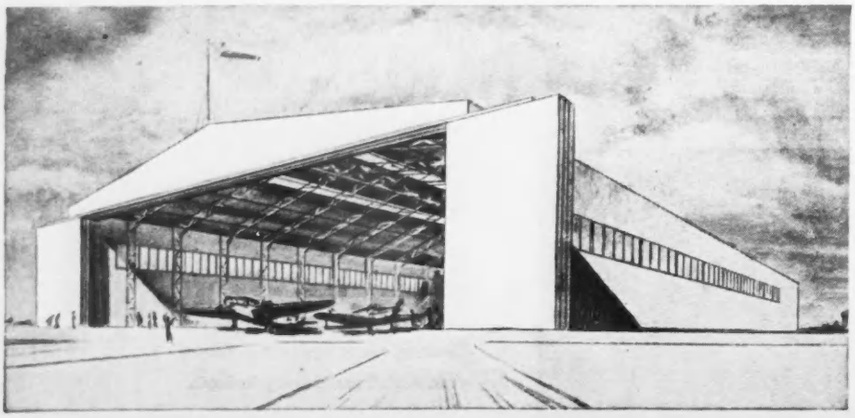

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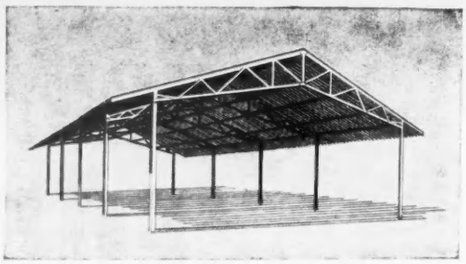
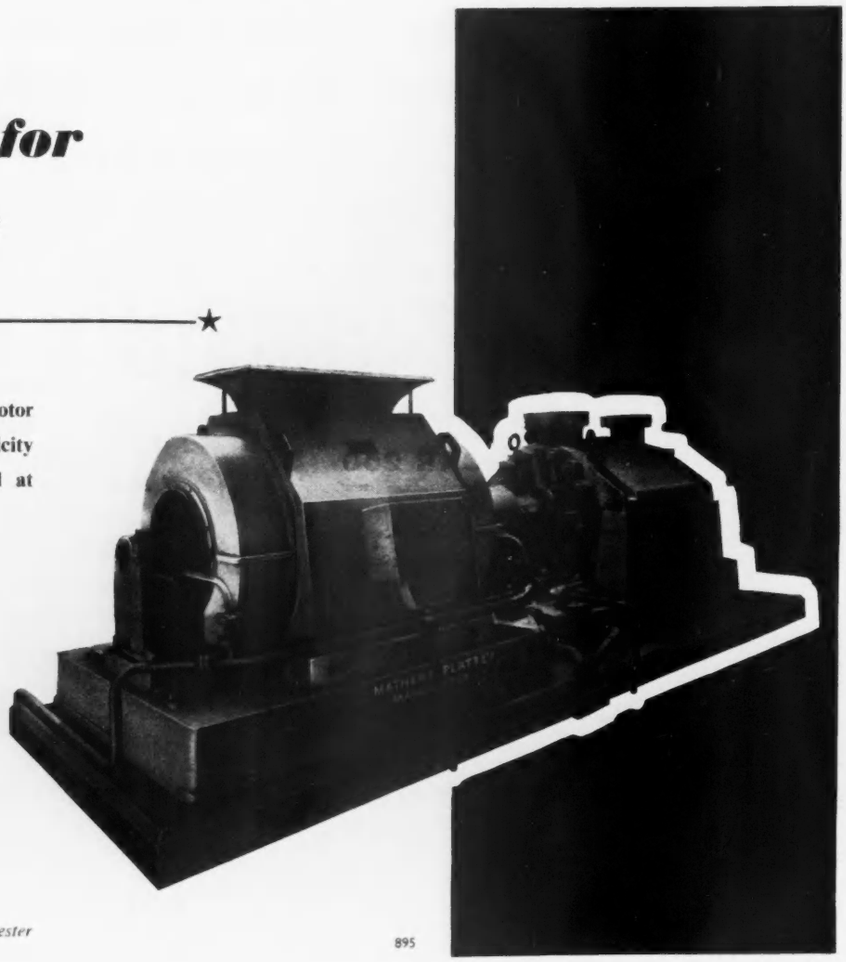


Pumping Sets for Power Stations



A Mather and Platt drip-proof squirrel-cage motor driving a boiler feed pump in a Central Electricity Generating Board generating station. It is rated at 1350 b.h.p., 2965 r.p.m., 3300 v., and is direct-on started with a low starting current. The Mather and Platt Plurovane pump delivers 600,000 lb. of feed water per hour at 260° F and 1210 lbs./q. in.

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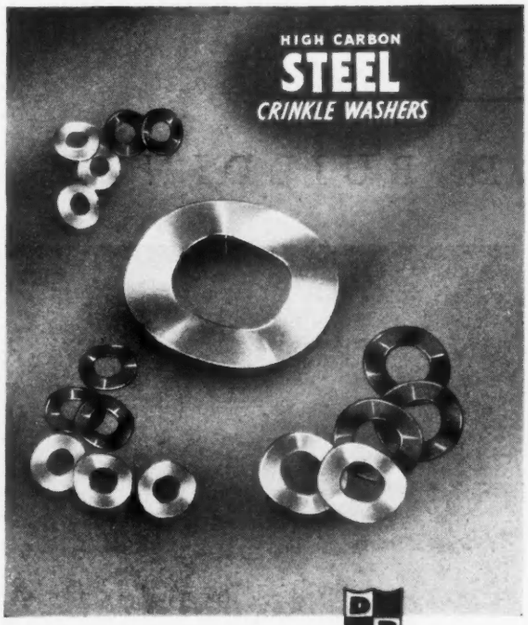

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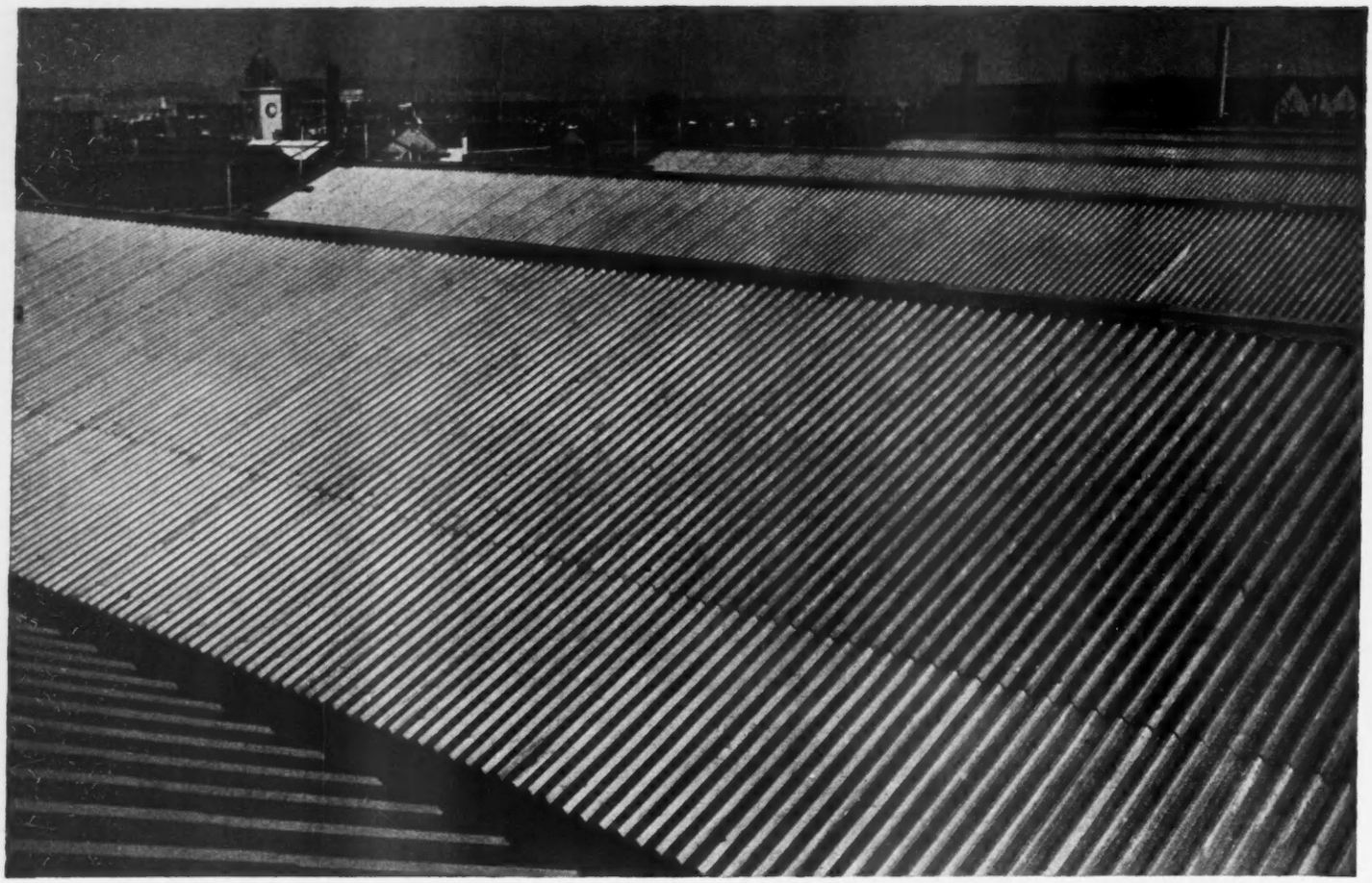

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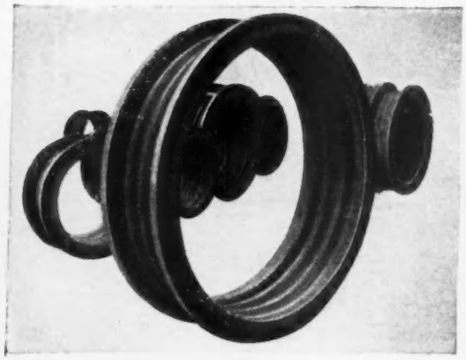

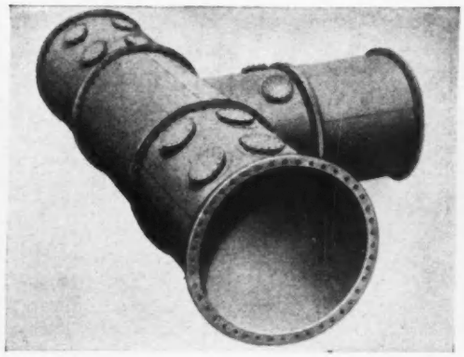

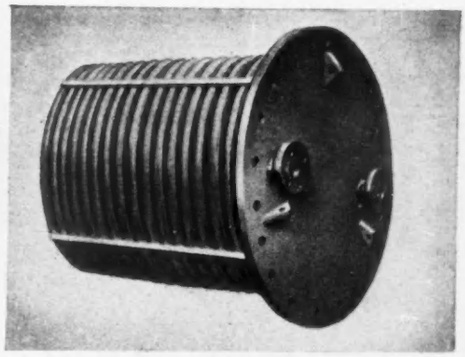

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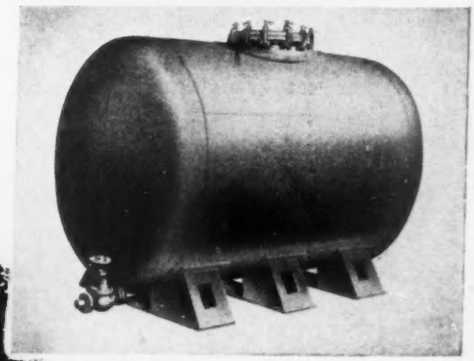

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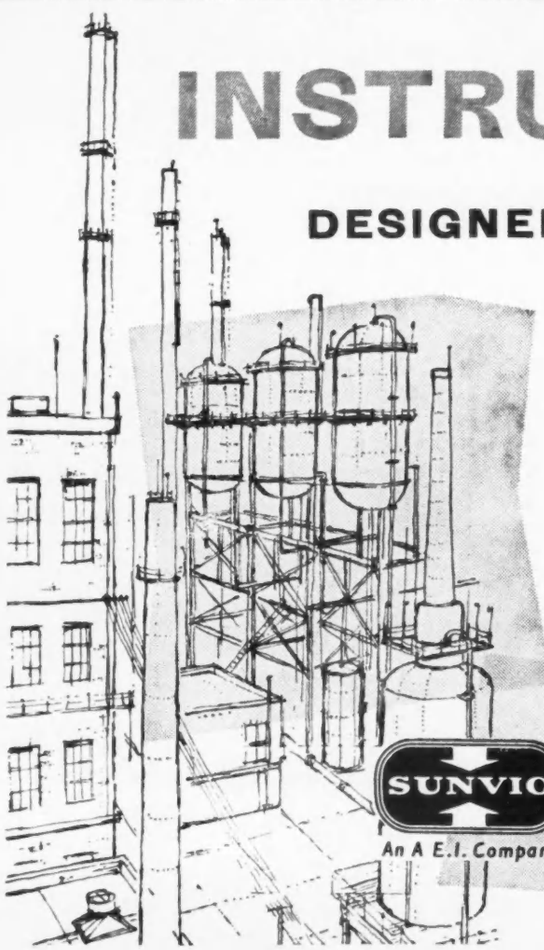

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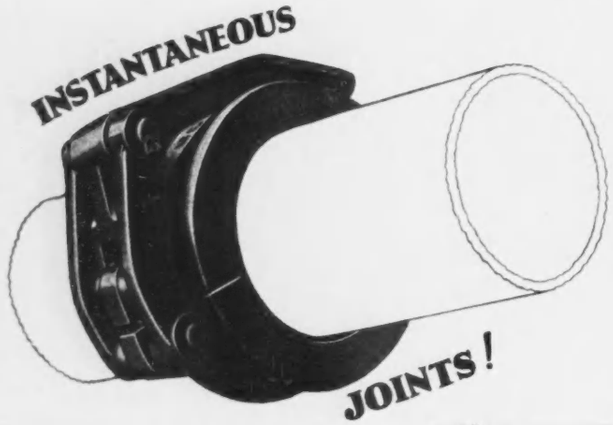

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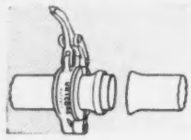
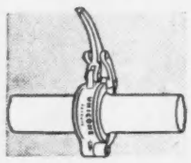
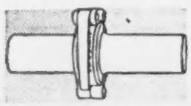


Rubber gasket in position and joint ready to pull over.



Pipe ends joined ready for locking.



The completed joint.

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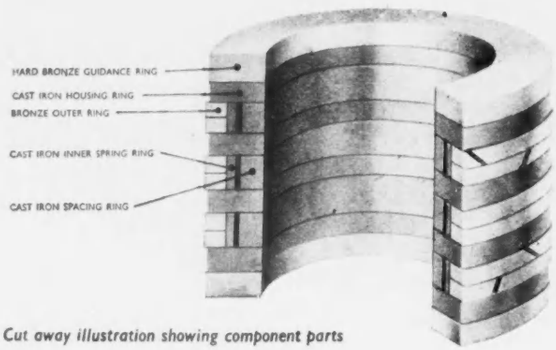

Cut away illustration showing component parts

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X AMPLIFIERS. Input Impedance: 1 megohm shunted by 50 pF approx. Amplification: 11 to 210 continuously variable. Frequency Response: D.C. to 150 Kcps 10% down. D.C. to 300 Kcps 30% down. Output Swing: 440 volts at a mean level of 150 volts above earth. Linearity of output: ±2%.

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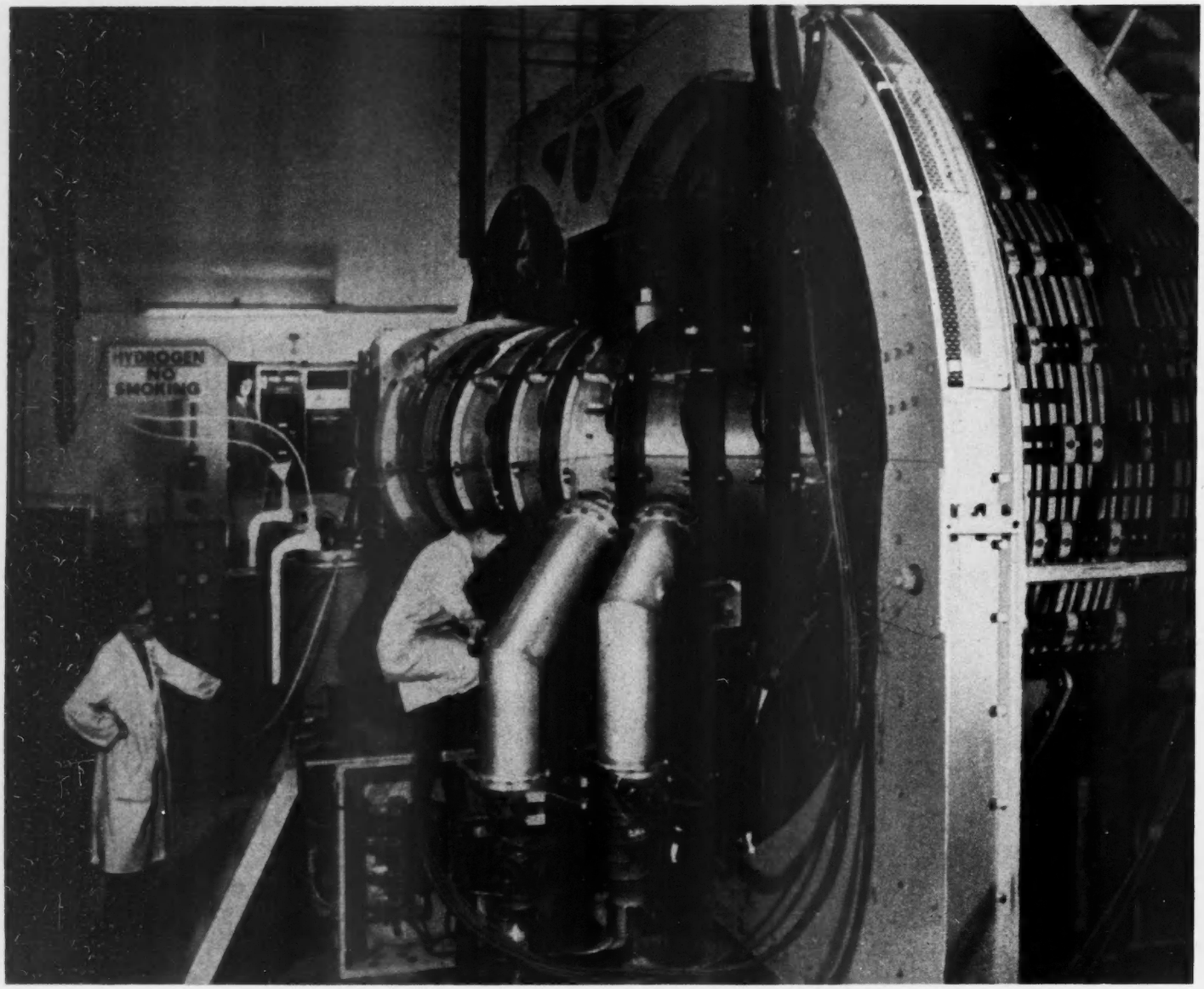

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P.46

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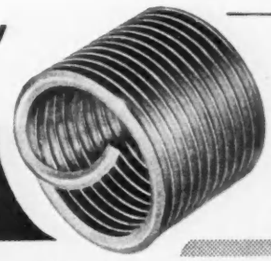

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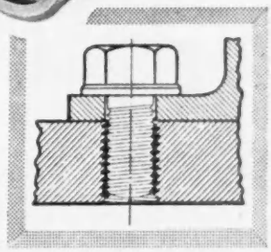

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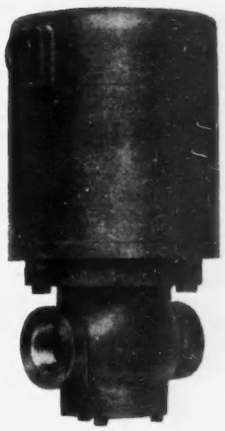

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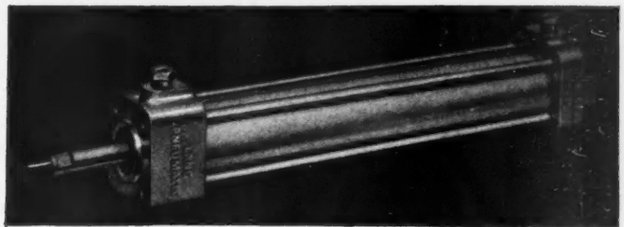

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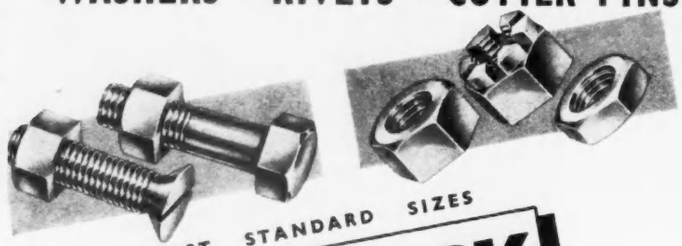

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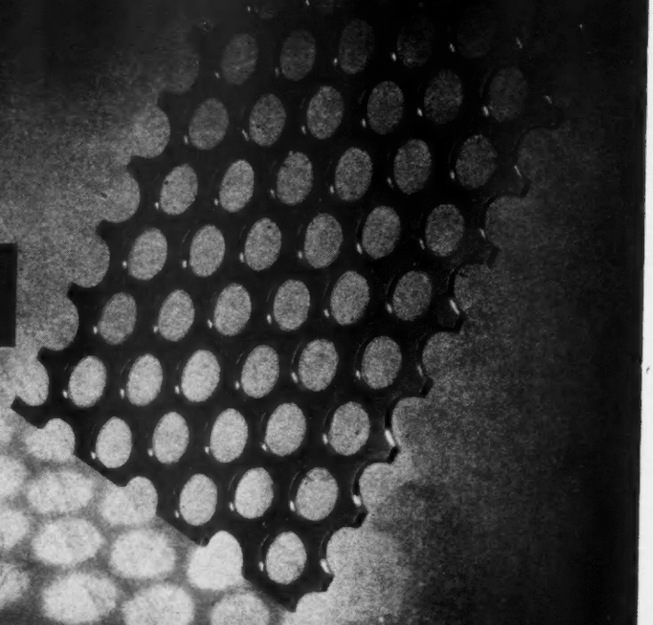

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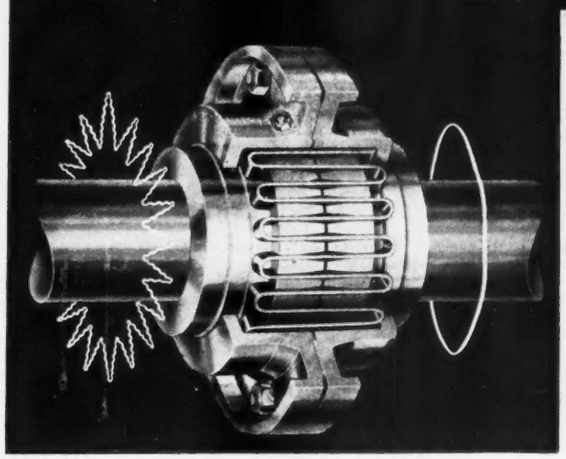

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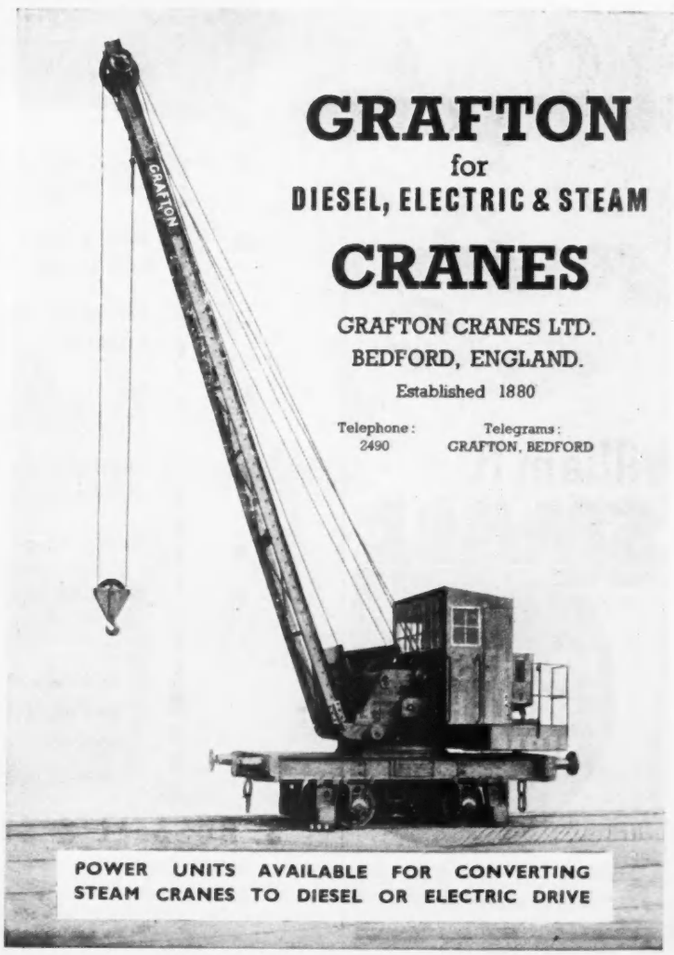

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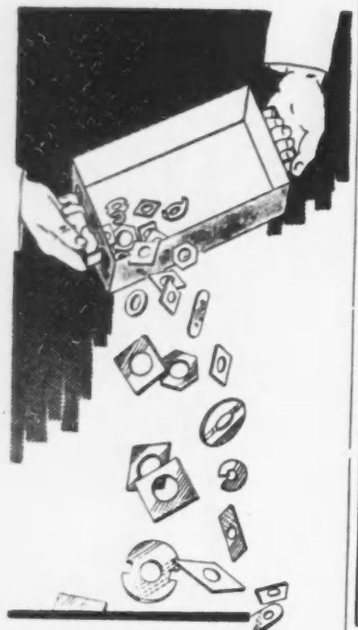

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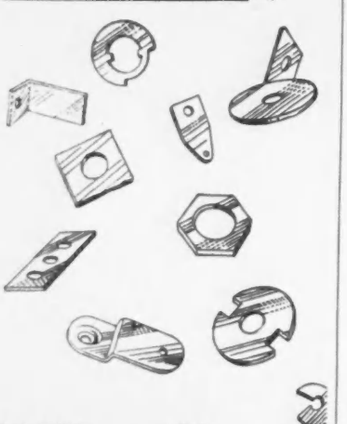

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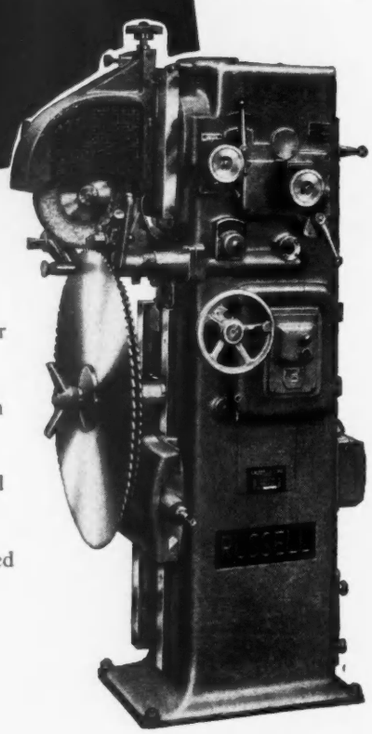

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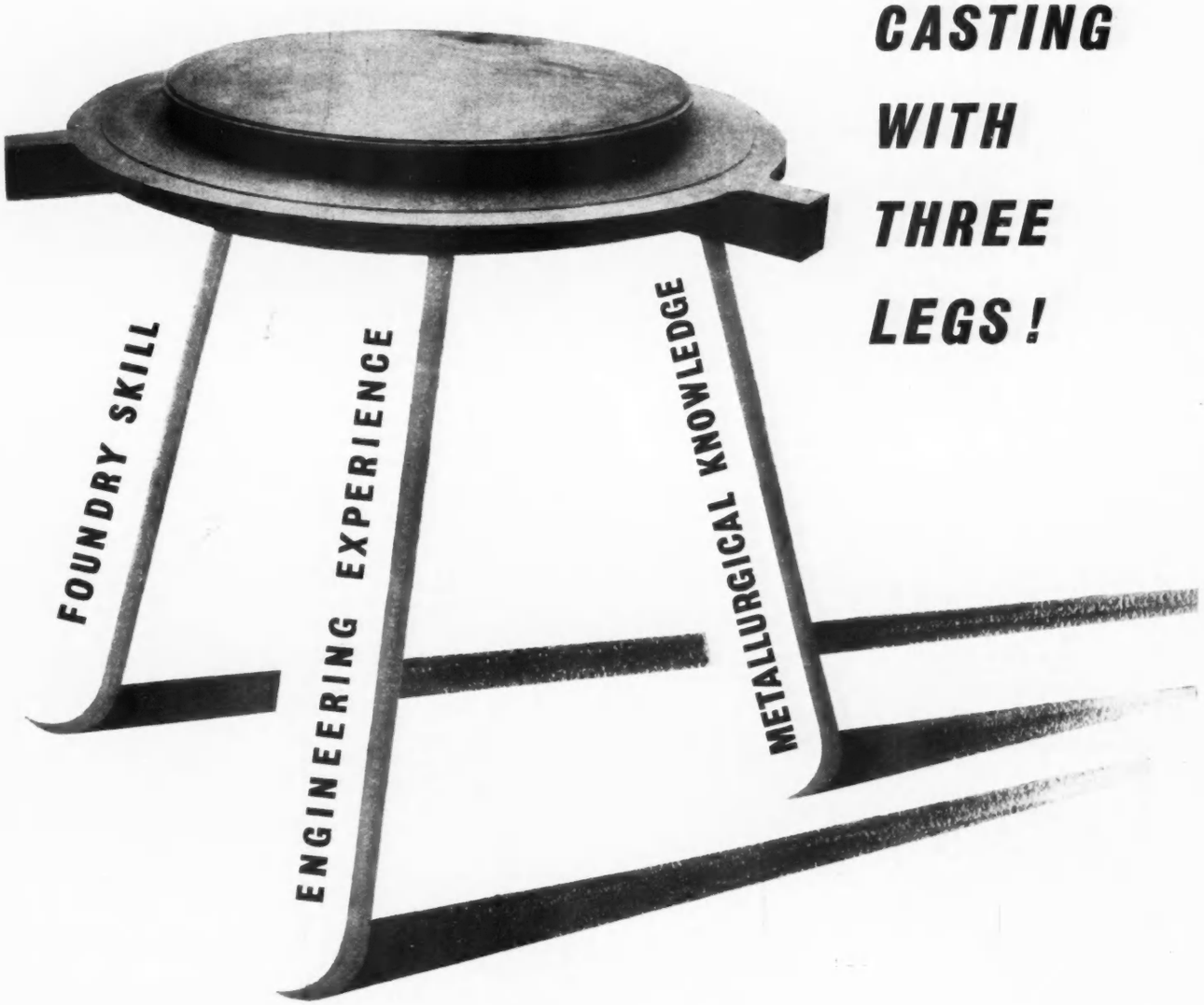

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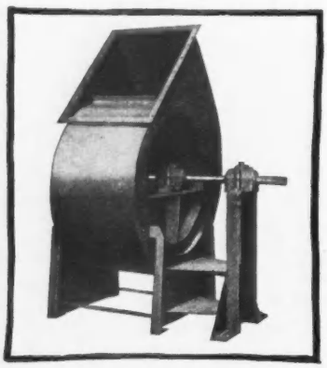

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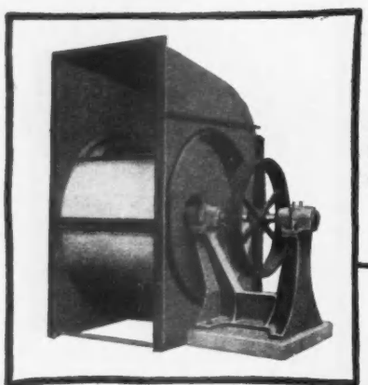
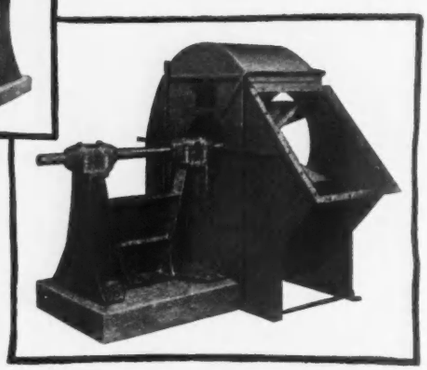


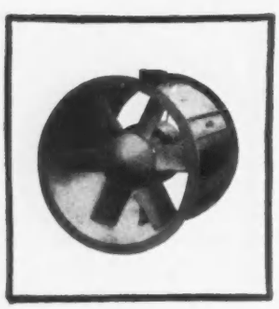
SLOW SPEED MULTIVANE FAN (Large size).

Air ways

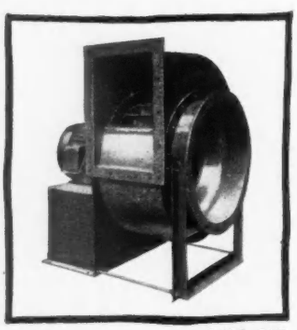


PADDLE BLADE FAN.

are our ways



AXIAL FLOW FAN.



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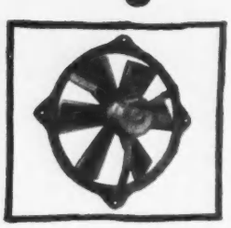

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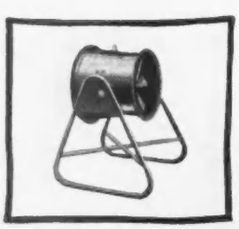

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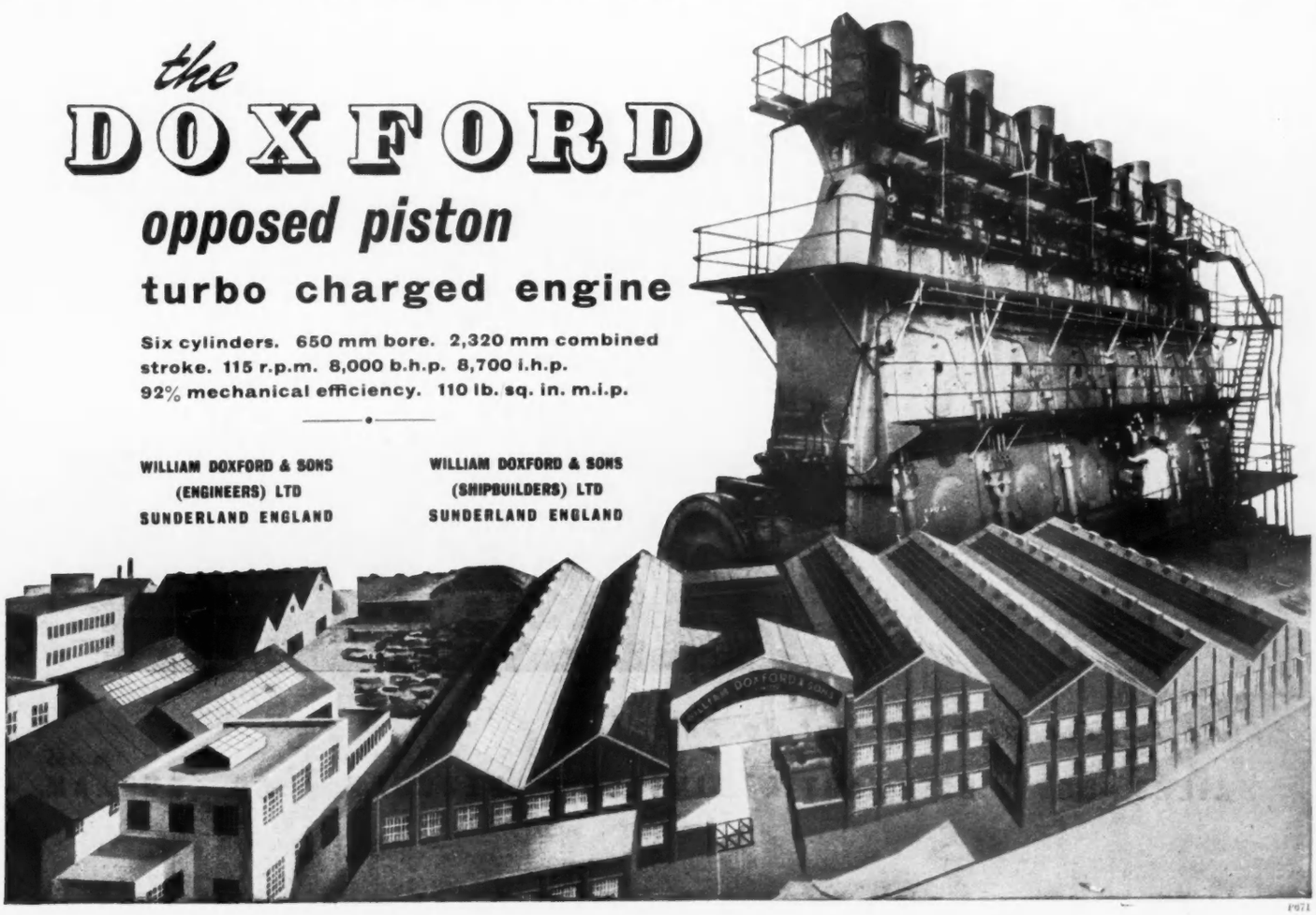

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Max. Turning Diam… with Side H…			
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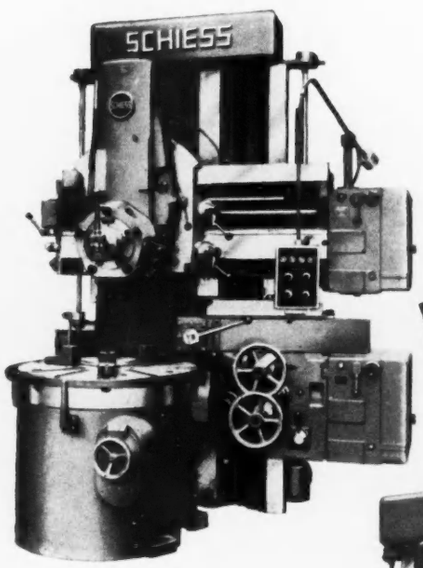
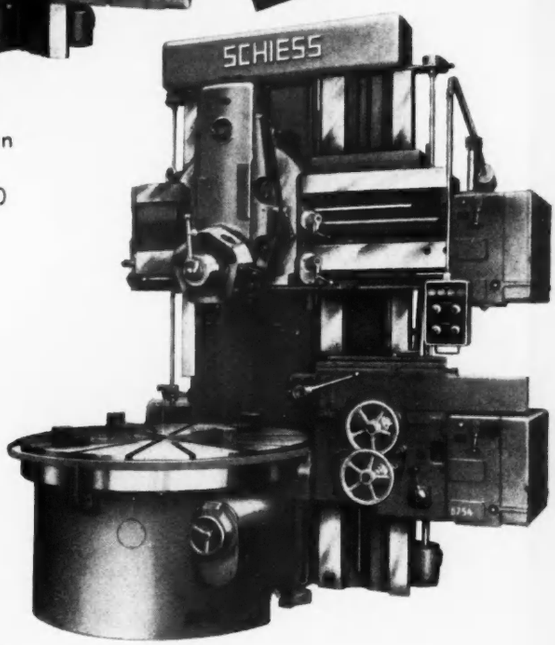
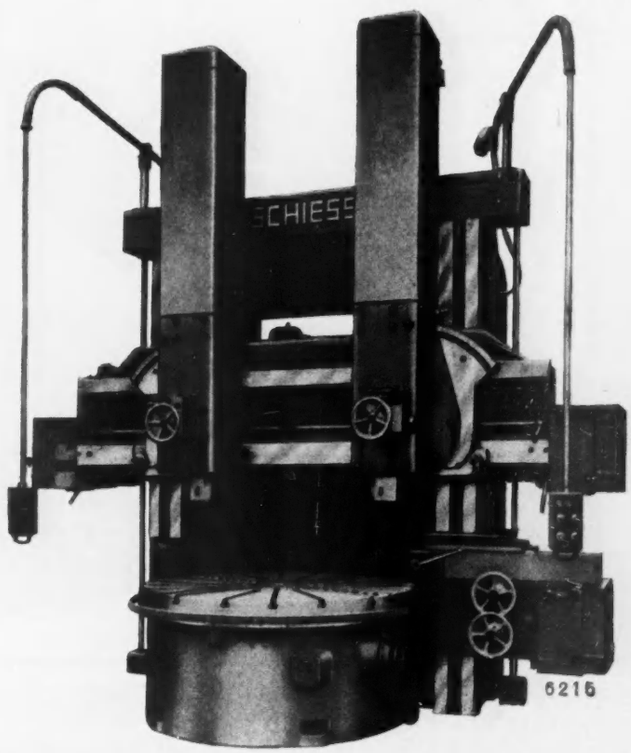
Table r.p.m.	6.2-310	4.7-237	3.8-191
…mber of Horizontal and Vertical Feeds	12	12	12
Range of Feeds per Revolution of Table ins.	.0026 – .26	.0026 – .26	.0026 – .26



Single Column Boring Mill Model K E 100



Single Column Boring Mill Model K E 160



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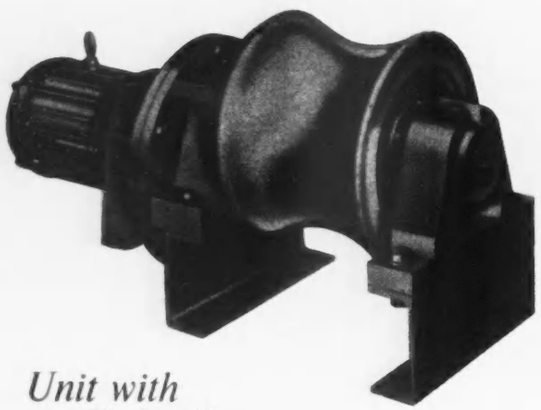

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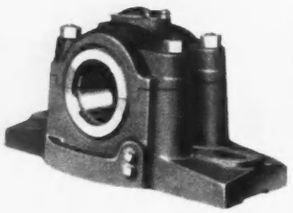
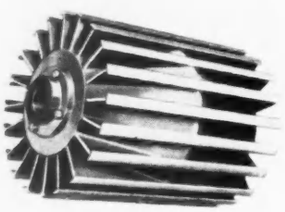
Conveyor Drives. Publication 853.



Plummer Blocks, plain, ball or roller bearings. Publication 5734.



Belt Saver Conveyor Pulleys. Publication 5715

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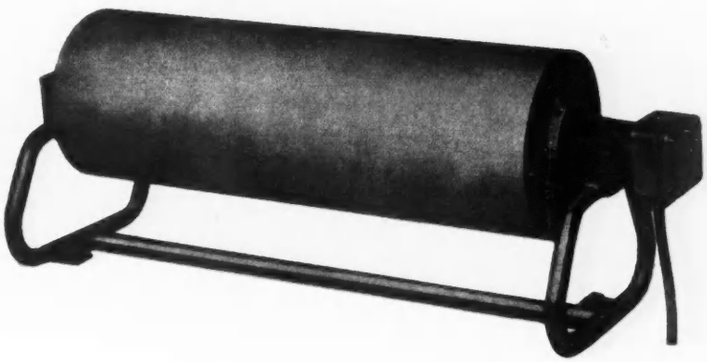

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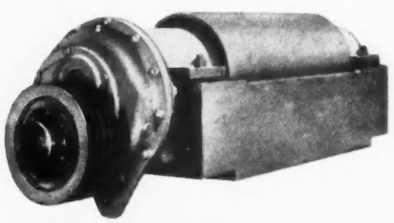

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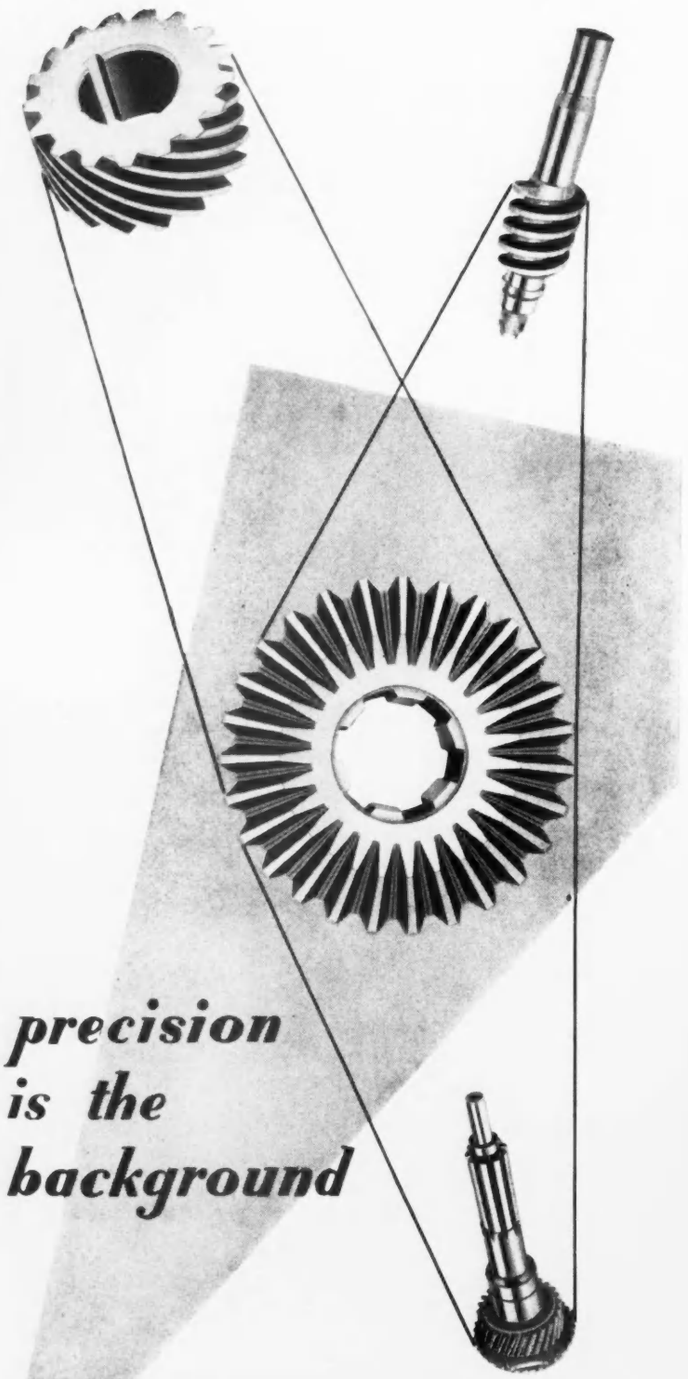

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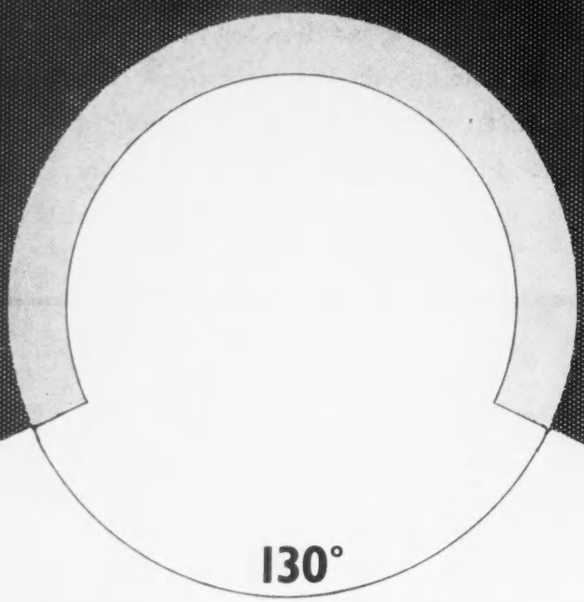

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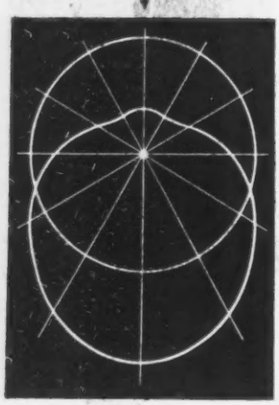

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LIGHT DISTRIBUTION COMPARISON DIAGRAM

Available in	SWITCH START
Cool White	4' 40W. 13/9d. plus P.T.
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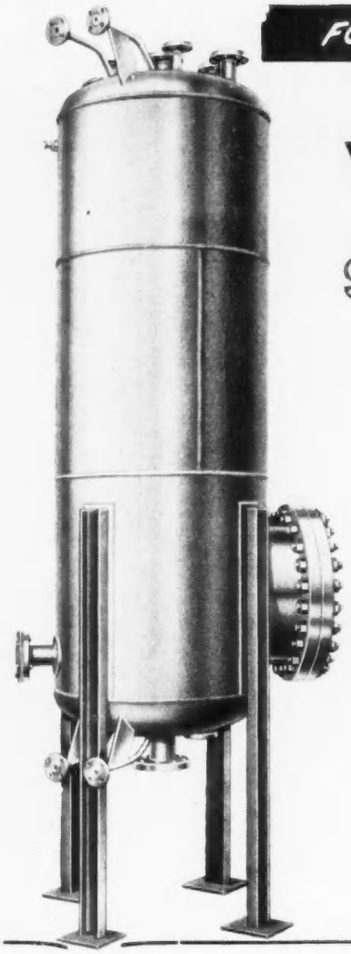

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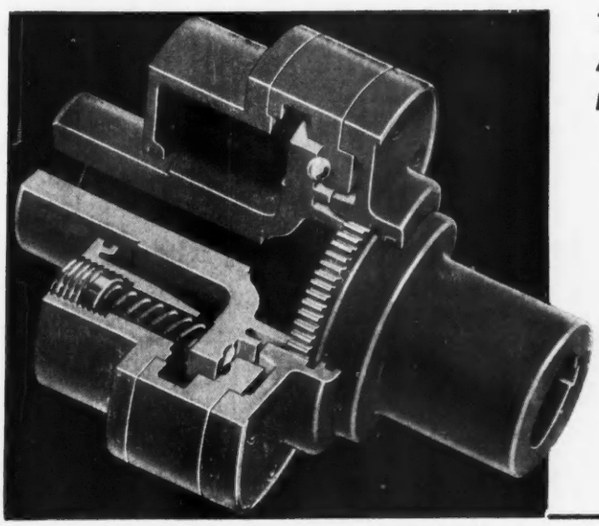

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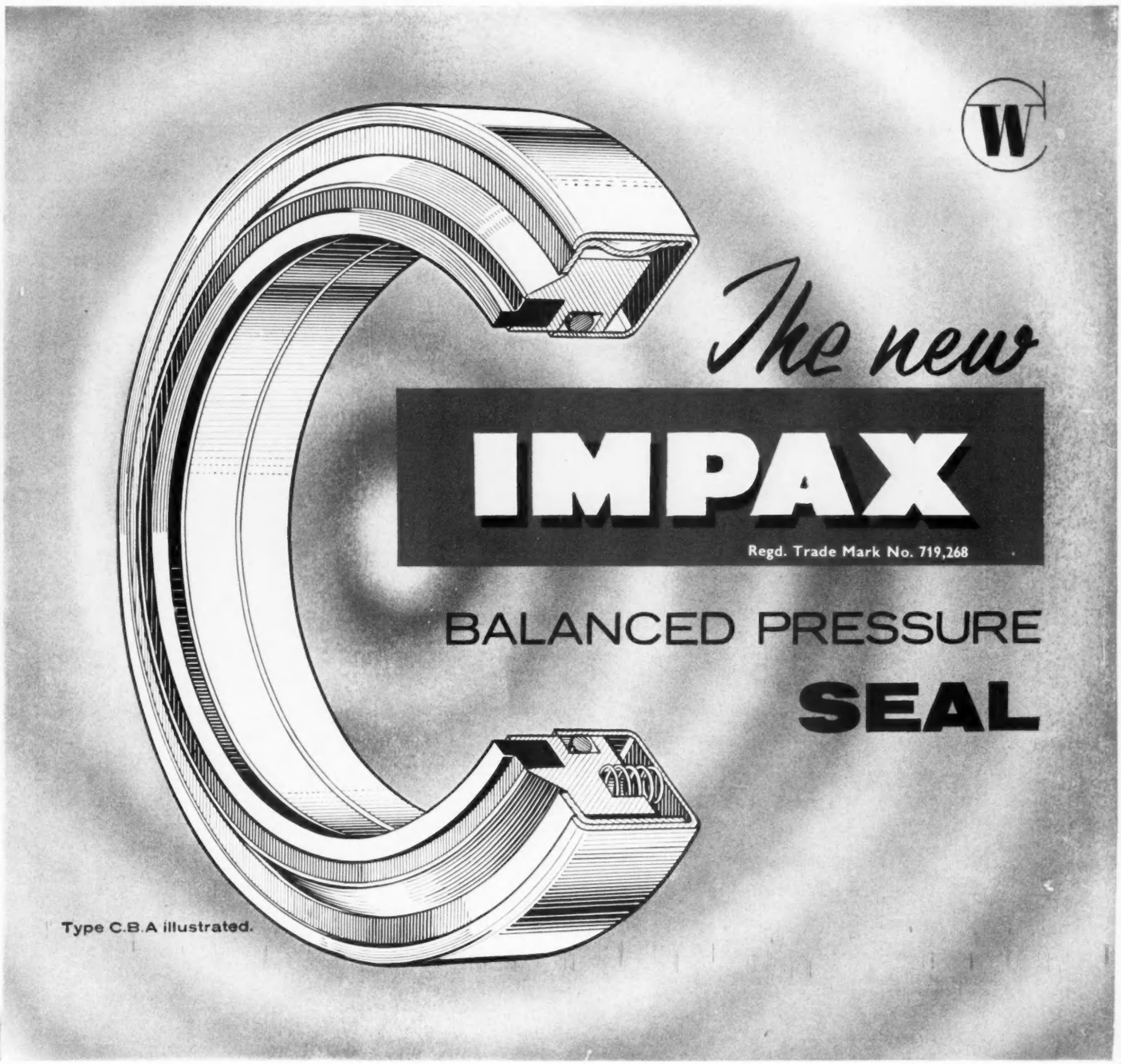

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Rough handling in transportation and during the process of laying is almost inevitable. If the pipe installed in position is to remain resistant to corrosion, the protective sheath must be tough enough to withstand the normal hazards of transport by road, rail or ship, and any accidental blows associated with standard pipe-laying practice.

The new woven-glass-reinforced sheathing, devised and introduced by Stewarts and Lloyds, has proved itself to be the answer to the problems of ensuring efficient protection against corrosion of the INSTALLED pipe. The mechanical strength of standard bitumen-asbestos sheathing is greatly increased by a wrapping of woven glass cloth. This is applied concurrently with hot bitumen-asbestos mastic and embedded just below the surface.

The glass cloth is manufactured entirely from glass fibres loosely twisted into a yarn

STEWARTS

which is woven to give an open mesh fabric somewhat similar, as regards gauge and mesh, to hessian cloth. The fabric is inert, electrically non-conducting and has a high tensile strength.

This woven-glass-reinforced sheathing will withstand sharp blows without damage, and even under harsh treatment the damage is confined to a superficial layer outside the glass wrap, leaving ample thickness of protective material for the corrosion-resistant property of the protection to remain unimpaired.

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The North Thames Gas Board, for the Shellhaven to Romford Refinery Gas pipeline.
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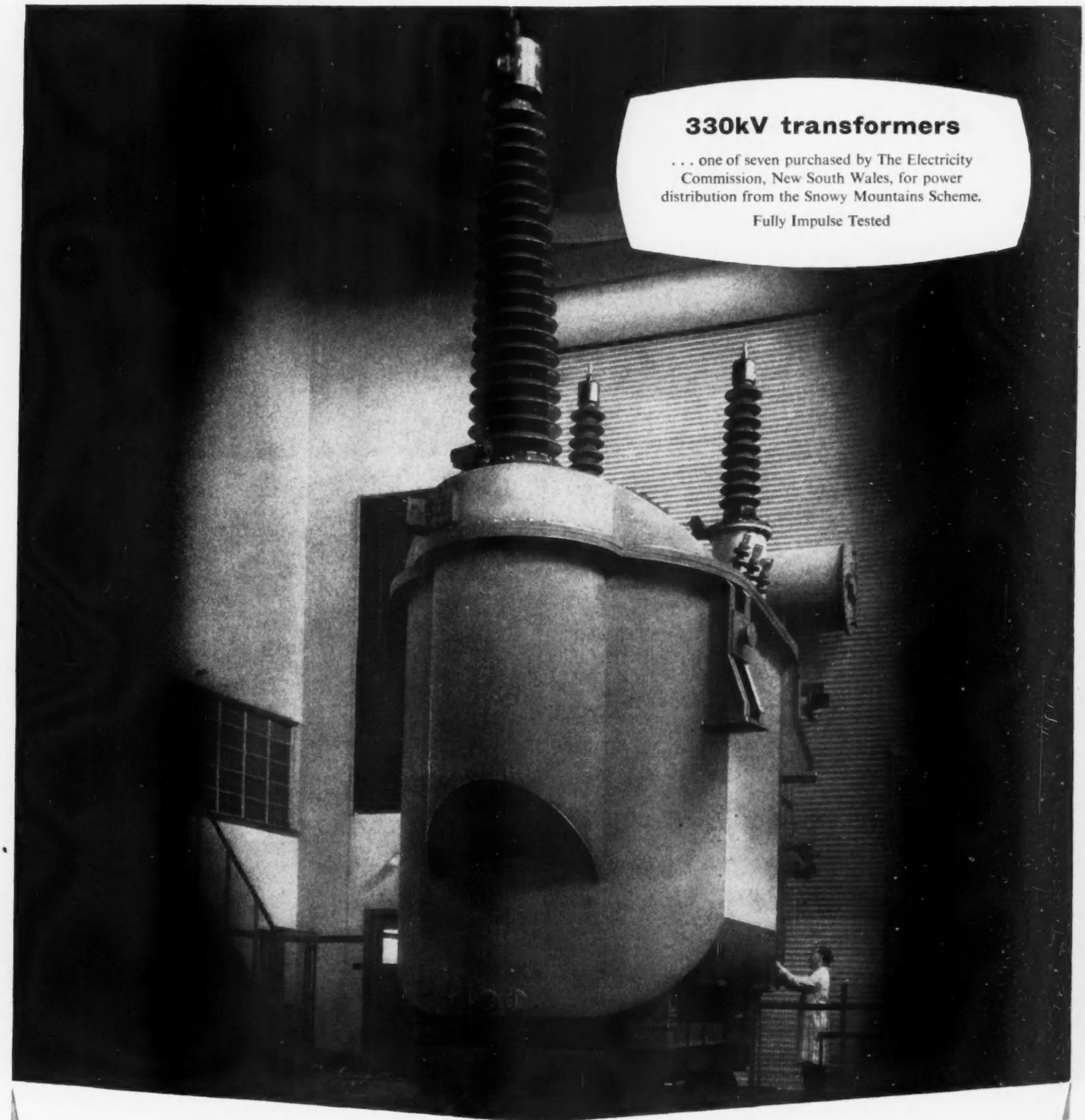
330kV transformers
. . . one of seven purchased by The Electricity Commission, New South Wales, for power distribution from the Snowy Mountains Scheme.
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transformers

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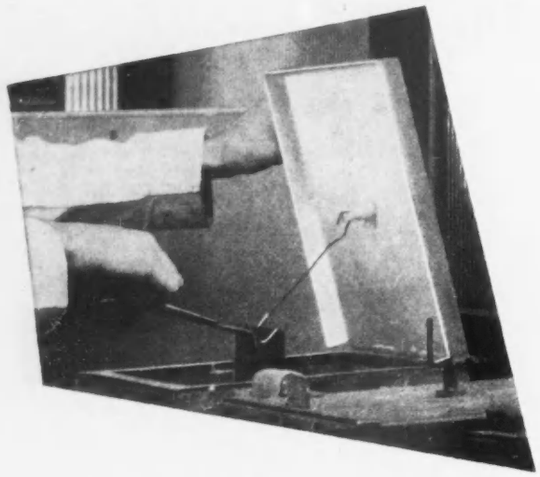
Are these hands helping *you?*



These hands are but a pair among many engaged in the continuous testing and experimental work carried out in P.J. laboratories, where skilled paint technicians tackle the complex problems which confront industrial paint users. Your area P.J. technical representative will bring you the services of this team of experts to advise and assist you with your finishing problems.

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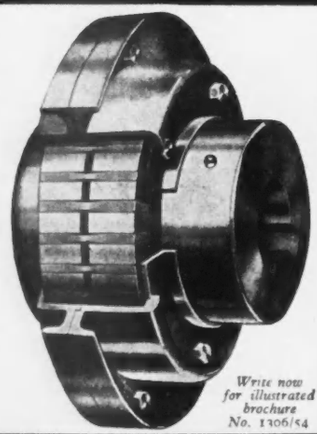
THE SECRET IS IN THE DESIGN It is the shape of the springs—separate individual keys which give the high degree of efficiency.

Greater safety as stresses are equally divided. Perfect balance at all speeds. Rarely requires lubrication, as a lubricant is packed inside couplings.

Smaller total diameter to transmit a given torque than other couplings of similar type.

Machined all over. Capacity from ·0125 to 24·80 B.H.P./R.P.M.

Diameter from 4½ to 38 ins.



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THE FAIRITT SERIES

Our range of Air Diffusers includes:

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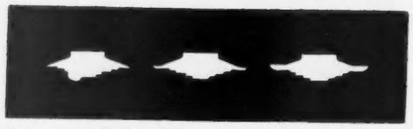
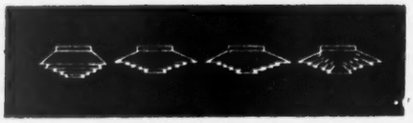


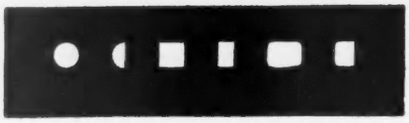
Main types, A, B and C.

4



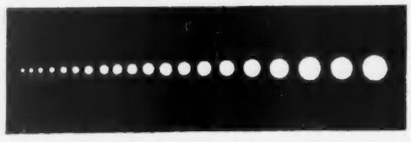
Variations, High level, Low level, etc.

6



Different Shapes, Round, Square, Rectangular and Half Round, Half Square, and Half Rectangular.

20



Different Sizes for most types, shapes and variations.

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different diffusers.

In addition there are two kinds of dampers, and an airsplitter and damper available for most sizes, two kinds of metal are available and three different finishes for 300 different colours; and, what is more, we are constantly adding to this range.

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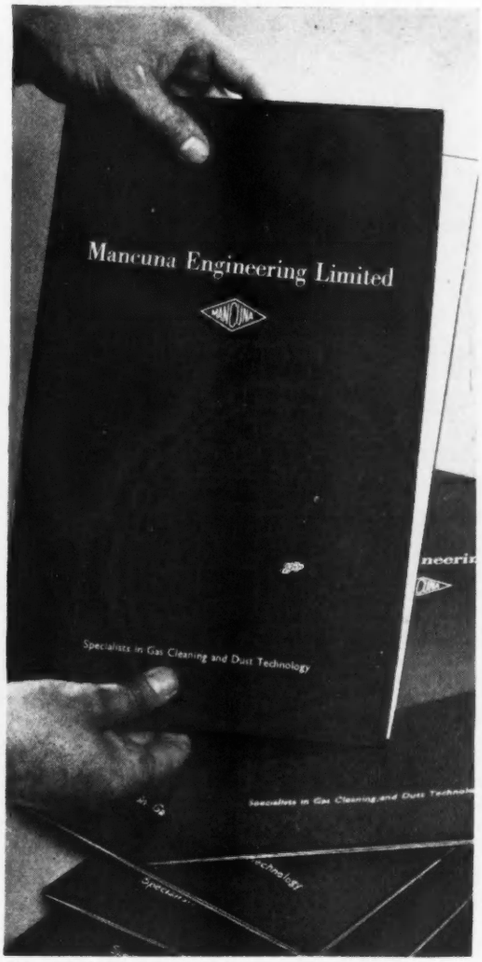

Memorandum on a dangerous subject

This memorandum was written, primarily, for the information of nuclear engineers on dust extraction, but as in so many branches of Nuclear Engineering, the specialised equipment applied to dust separation in Atomic Energy Stations is but the outcome of research and development on the best standard equipment available to industry at large. The Memorandum describes our methods and approach, and a further booklet, " Dust Extraction and Collection," describes the equipment available for general High Efficiency Recovery of valuable and nuisance dusts from Milk Powder to Boiler Grit.

A brief request on your firm's letterhead will ensure you copies of both these interesting documents.

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Specialists in Gas Cleaning and Dust Technology
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Town's gas-fired Twenty Strand Wire Annealing Furnace for bright annealing high nickel wire of all gauges

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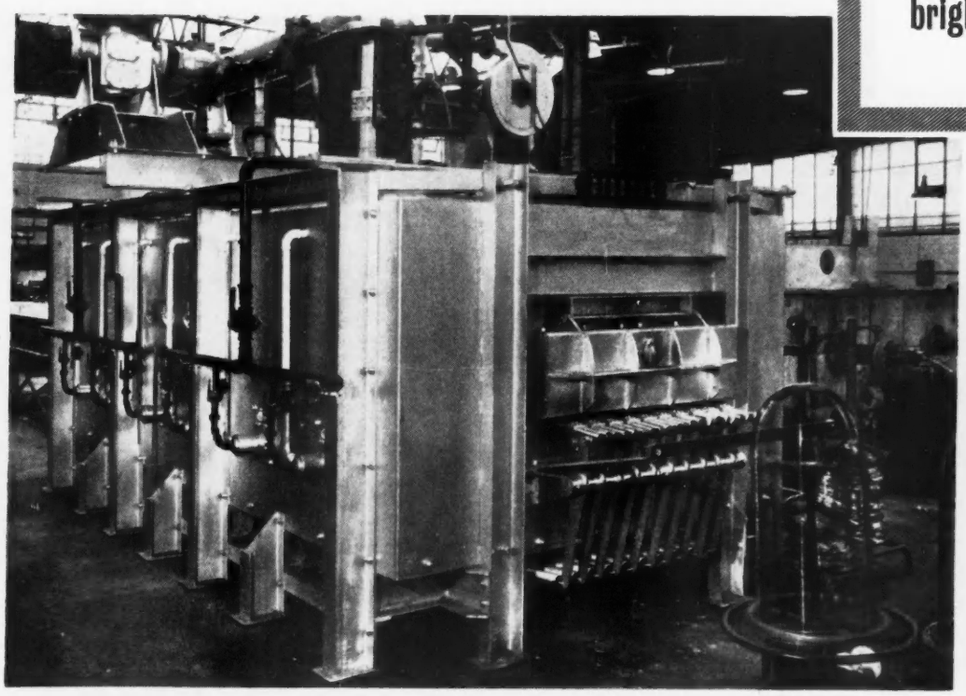

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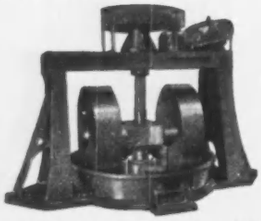

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We've always said that Unbrako screws cost less than trouble.

But it happens that once in a while a customer needs a screw that cannot be found even in the vast Unbrako range.

So we make them to the customer's own specification, or design specially for him.

And even when we have to make specially, Unbrako still costs less than trouble.

So, rest assured, standard or not, you can always safely specify Unbrako screws and make sure of getting the finest fasteners that are made anywhere in the world. Details of sizes and threads will gladly be sent on request.

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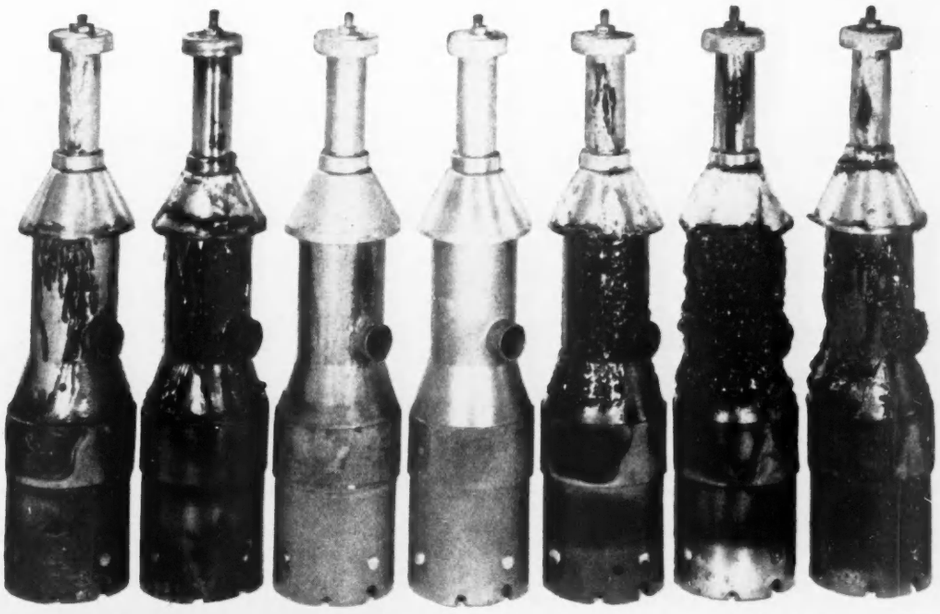
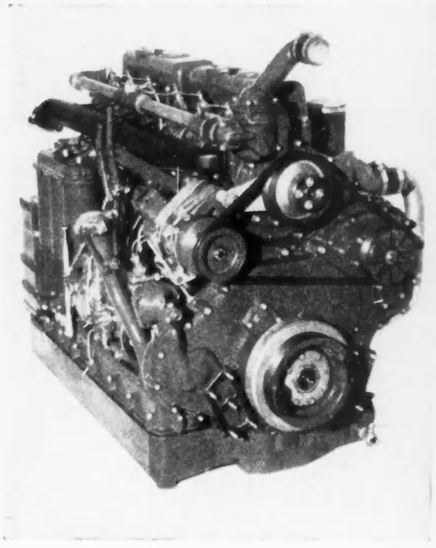


. . . in pump assemblies

Jet assemblies used in a SPEEDIVAC* Model 203 vapour diffusion pump during a test in which the pump operated for fifteen minutes and then air was admitted for five minutes. The jet assembly in the centre using MS703 silicone fluid had survived over 1,000 such cycles yet remained clean. The organic fluids in the other assemblies either failed or lost the ability to pump down to a high vacuum.

**Trade name of Edwards High Vacuum Ltd.*



MS

SILICONE FLUIDS

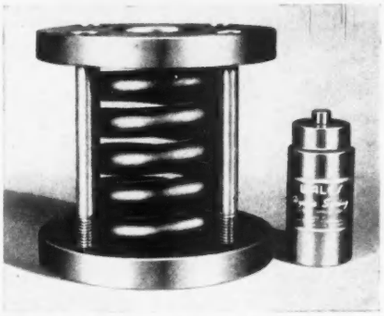
ensure peak performance over a wide temperature range

SILICONE FLUIDS are colourless, inert liquids ranging in viscosity from 0.65 to over 1,000,000 centistokes. They are heat-stable, resistant to oxidation and show remarkably little change of viscosity over a wide temperature range compared with other fluids. These properties make them excellent media for damping and hydraulic fluids, high temperature oil baths and special-purpose lubricants.

Silicone fluids are very resistant to shear breakdown. For instance, after 100 hours operation involving 18,000 cycles in a hydraulic system operating at 1,500 p.s.i. petroleum oil suffered a 50% decrease in viscosity. A MS 200 silicone fluid, after 500 hours of the same treatment had decreased in viscosity by only 15%.

. . . in torsional vibration dampers

This supercharged, six cylinder Rolls-Royce four-stroke diesel engine develops 275 h.p. at 2,100 r.p.m. The nitrite hardened crankshaft has seven main bearings and is equipped with a HOLSET torsional vibration damper which uses a high viscosity MS 200 fluid as the damping medium. The excellent shear stability of the silicone fluid as well as its good viscosity temperature characteristics make it highly suitable for this application.



. . . in liquid springs

A steel coil spring and a liquid spring of equivalent performance are shown. The liquid spring contains a silicone fluid which is highly compressible, will show little change in viscosity over a wide temperature range and will not break down even at high temperatures.

You are invited to write for full information about the properties and applications of silicone fluids. Literature on the many other MS silicone products including rubbers, resins, lubricants, compounds, electrical insulants, release and antifoam agents, is also available on request.

MS

TRW/MS 106

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(Associated with Albright & Wilson and Dow Corning Corporation)

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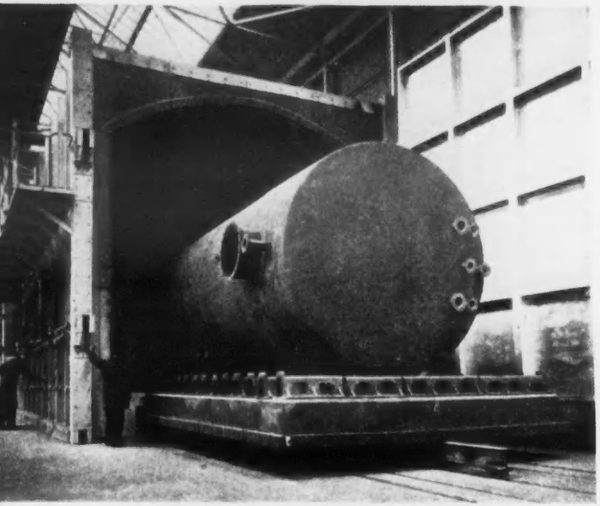
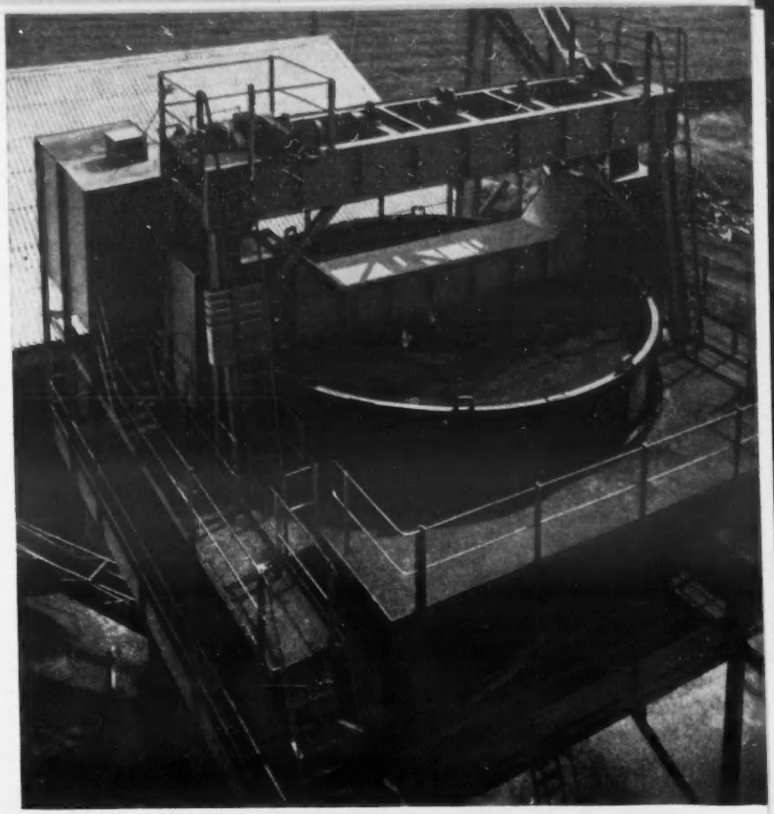
NEWTON CHAMBERS



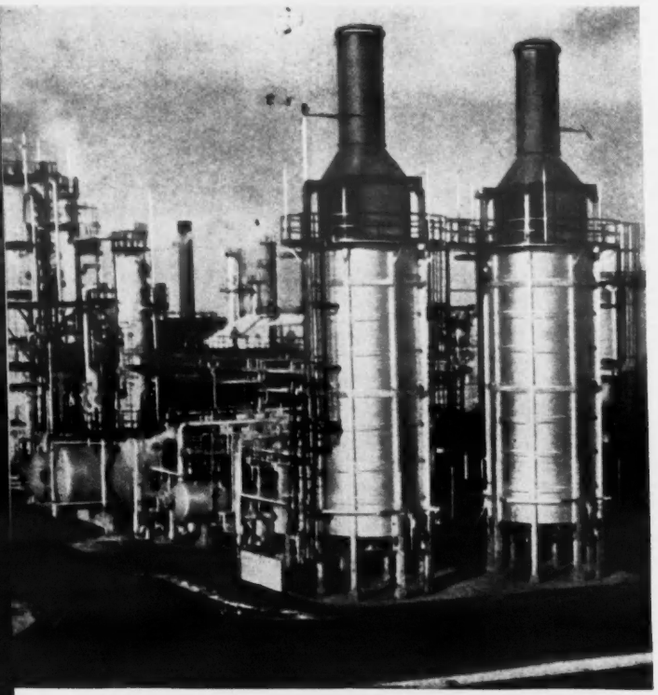
FOR MANY YEARS Newton Chambers have specialised in the design, fabrication and assembly of plant and equipment for the basic and heavy industries. This past year has seen many new developments and extension of production facilities. In addition to developments through our own research department we have made several important agreements with American and Continental organisations to manufacture the most up-to-date plant and equipment of their respective types in this country.

To deal with the increased scope the constructional shops at Thorncliffe have been extended and equipped to include facilities for welding to class 1 standards, stress relieving and X-ray examination. Today Newton Chambers are better equipped than ever before to provide a comprehensive service to industry.

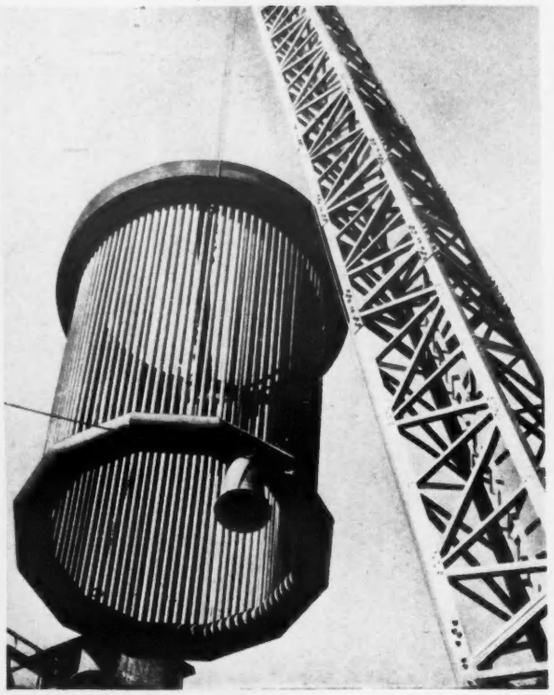
This stress relieving furnace included in the new facilities provided at Thorncliffe for welding to class 1 standards, takes vessels up to 15 ft. in diameter, up to 100 ft. in length and up to 70 tons in weight.



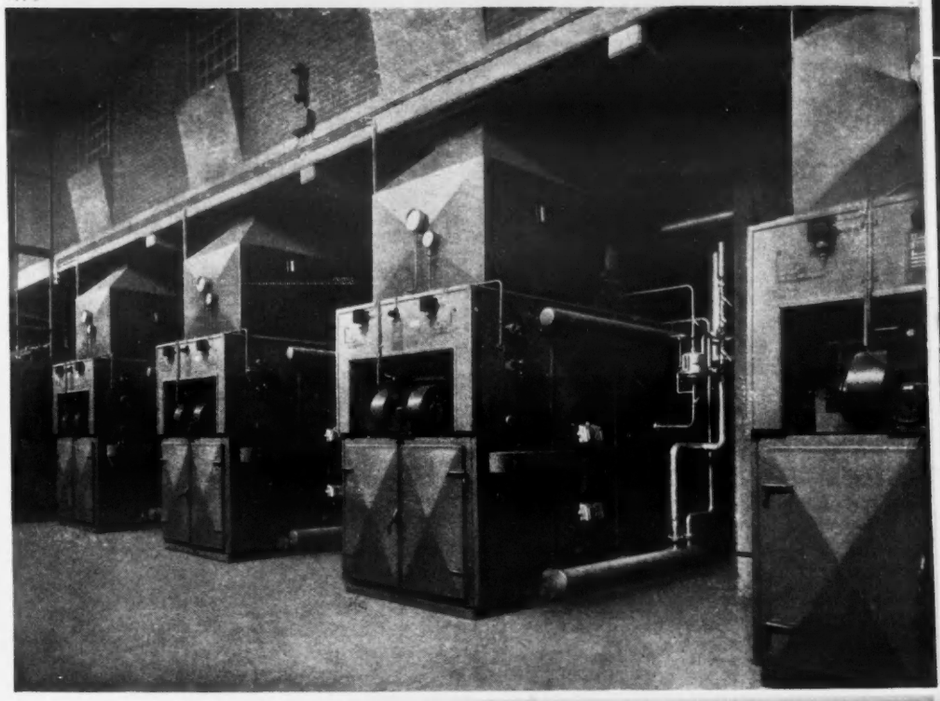
Newton Chambers continue to lead in the design of plant for the gas industry particularly with the mechanisation of tower purifiers. The new patented mechanical oxide discharger shown here is economical in operation, reduces labour requirements and is clean in action.



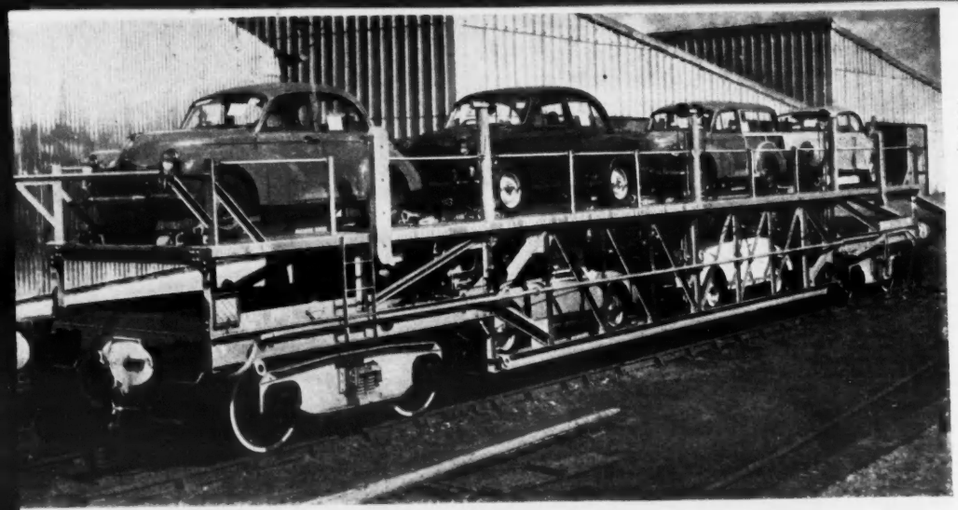
BELOW LEFT *Newton Chambers can offer direct to British industry the well-known Struthers Wells equipment for industrial heating at elevated temperatures.*



BELOW *The new radiant type Inka Preheater manufactured under licence from Industrikemiska extends our heat exchange equipment to deal with temperatures up to 875 degrees C.*



BELOW RIGHT *Redfyre Emma Coke Boilers are now manufactured at Thorncliffe to provide this country with the highest efficiency in central heating and hot water supply.*

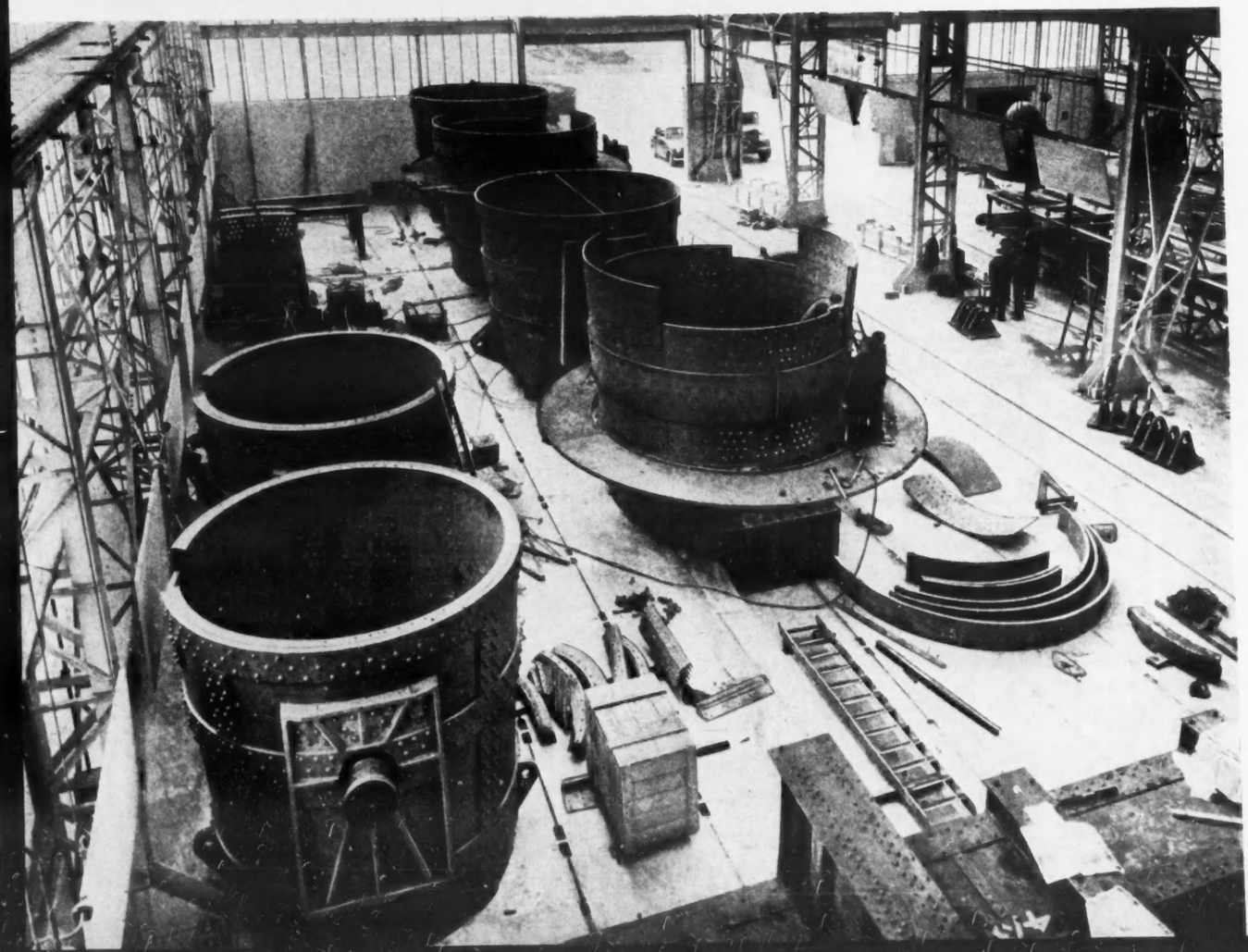


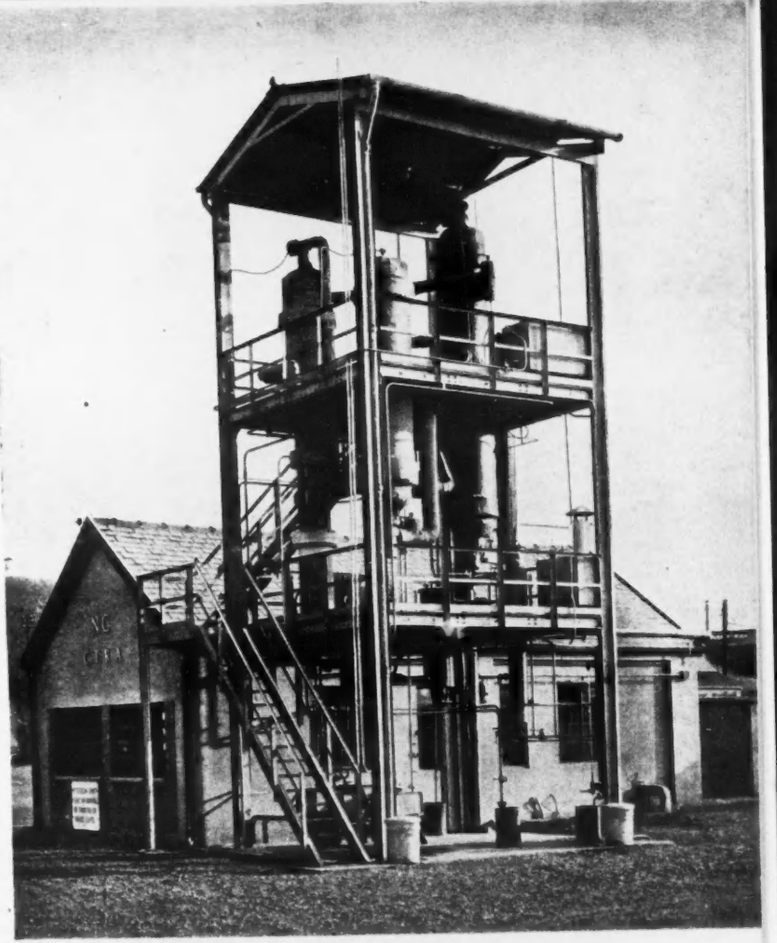
A new motor car transporter, the first of its kind has been developed. Two tier in type it will carry 7 motor cars and is suitable for British and Continental railways.

Newton Chambers

An outstanding result of research in collaboration with the Coal Tar Research Association is the new plant for the hydro-refining of Benzoles and Naphthas.

Further extensions to the constructional shops at Thorncliffe increase capacity for manufacturing larger industrial plant such as the 275 ton capacity ladles for the steel industry shown here.





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NEWTON CHAMBERS AND COMPANY LIMITED
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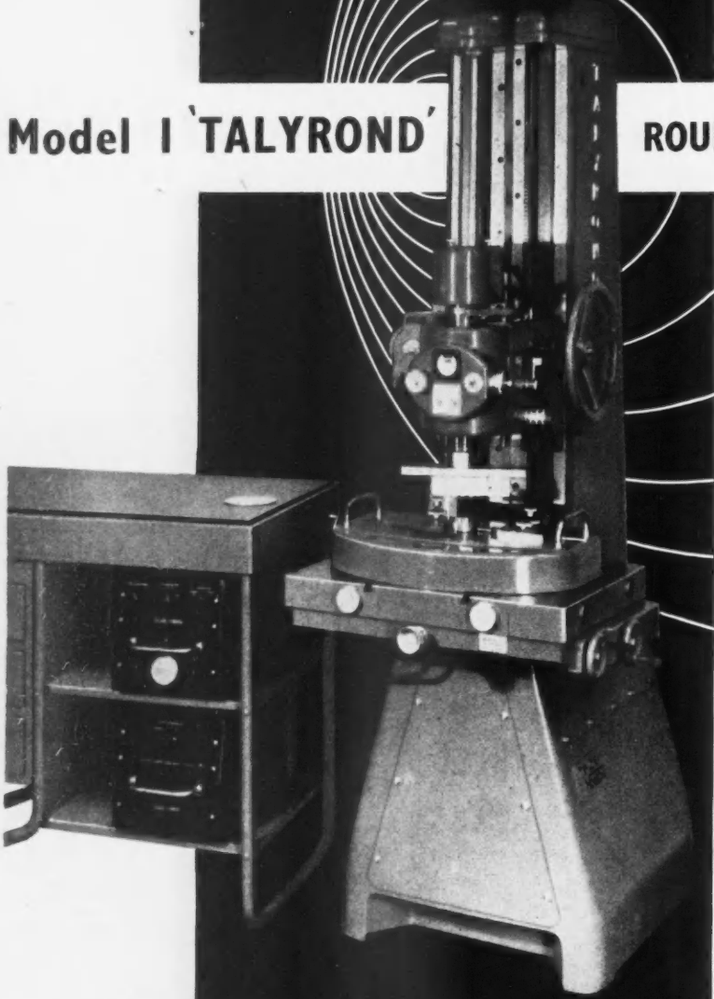
TAYLOR-HOBSON

Model 1 'TALYROND' ROUNDNESS MEASURING INSTRUMENT



Smoother, quieter for faster running.

Roundness is the key to smoother, quieter, faster running, and such qualities depend upon the correct geometric shape as well as dimensional accuracy.

The Taylor-Hobson 'Talyrond' Roundness Measuring Instrument will measure errors as infinitesimal as 3 micro-inches (.000,003-in), thus assisting in the analysis of manufacturing processes, leading to optimum performance.

TAYLOR TAYLOR & HOBSON LTD.
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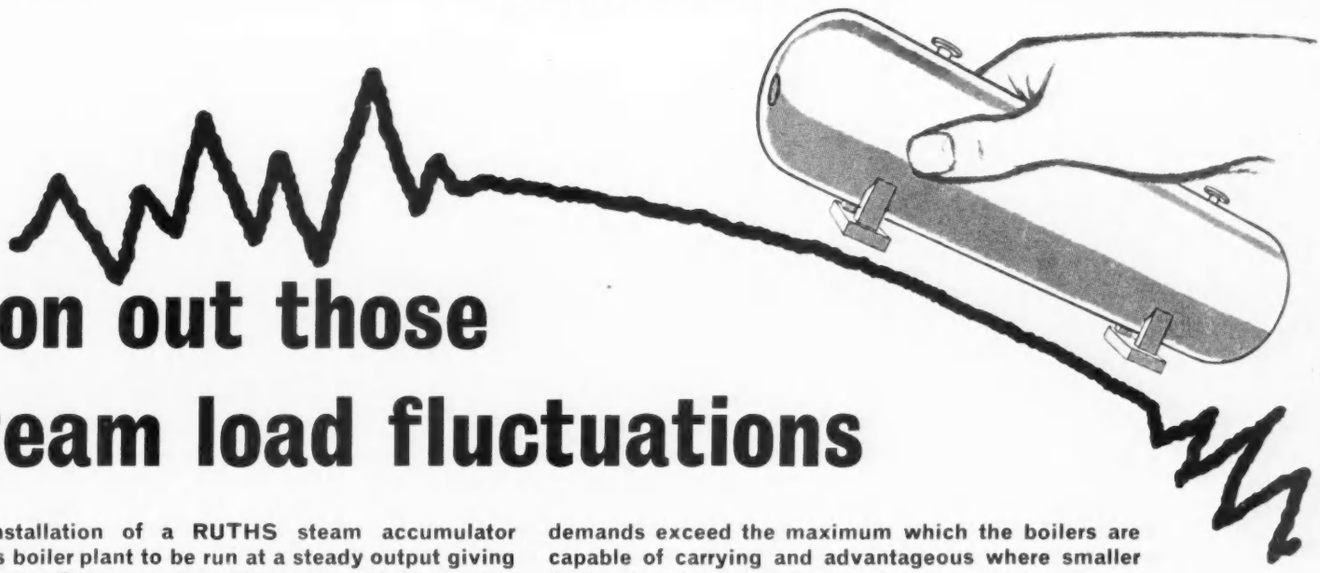
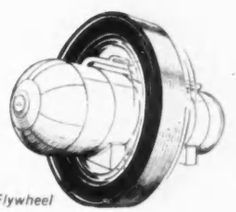


Iron out those steam load fluctuations

The installation of a RUTHS steam accumulator enables boiler plant to be run at a steady output giving maximum efficiency where there are widely varying steam demands. The accumulator also ensures a constant pressure in the process line at all times.
A RUTHS steam accumulator is essential where peak demands exceed the maximum which the boilers are capable of carrying and advantageous where smaller fluctuations in demand occur.
We would welcome the opportunity to investigate your problem and to submit proposals should we find that a case for steam storage exists.

RUTHS
Regd. Trade Mark

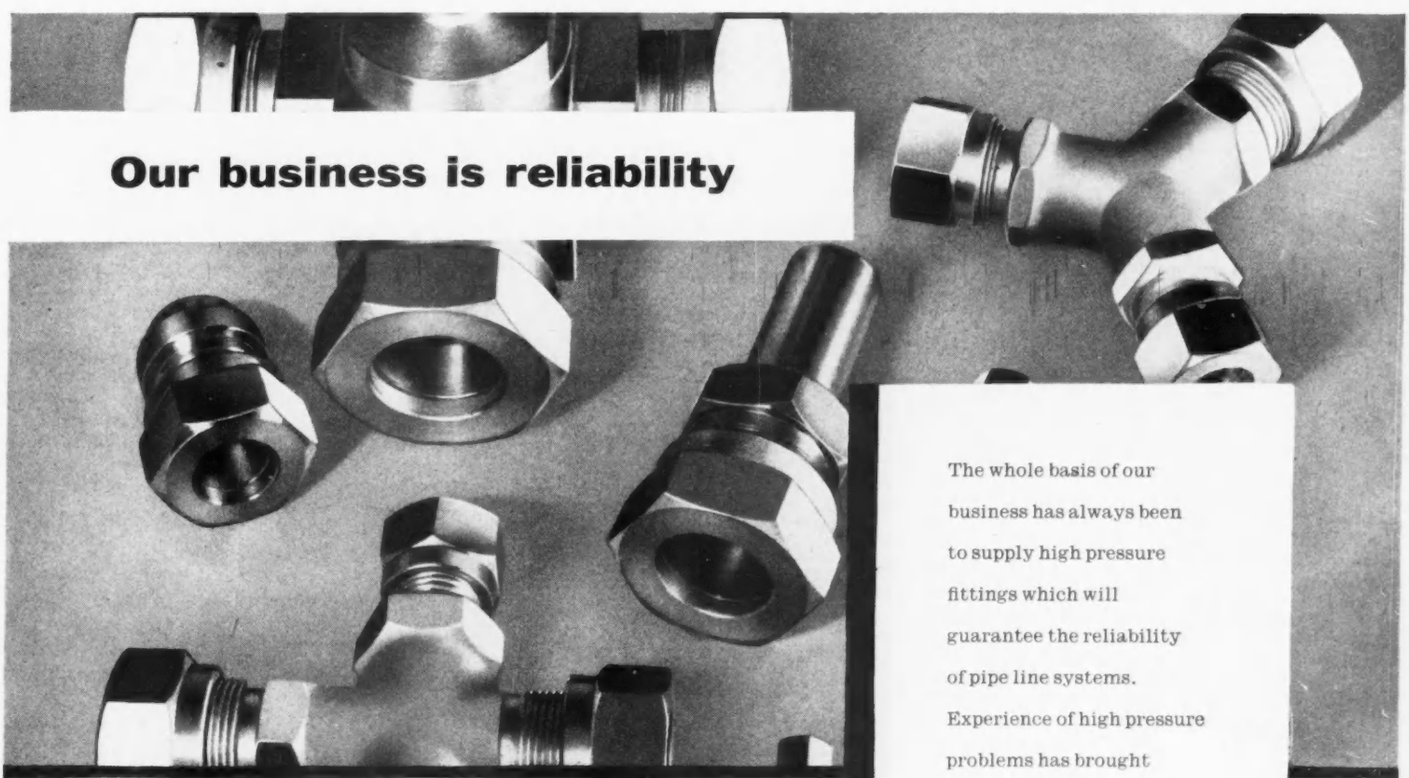
STEAM ACCUMULATORS



The Thermal Flywheel

COCHRAN & CO., ANNAN, LIMITED, Annan, Dumfriesshire, Scotland; and at 34, Victoria Street, London, S.W.1.

TAS/CH 635



Our business is reliability

The whole basis of our business has always been to supply high pressure fittings which will guarantee the reliability of pipe line systems. Experience of high pressure problems has brought with it the large range of fittings now produced by Ermeto.

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Details of high pressure couplings and valves will be sent on request.

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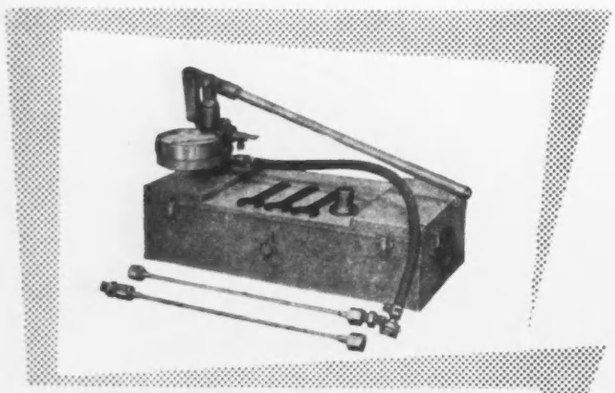

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Maximum pressures up to 10,000 lb/in.², with minimum of effort · Other models for lower maximum pressures · Supplied with strong wooden carrying box, on which pump is also mounted for use · Gunmetal and Steel construction · Can be supplied without boxes · Rubber suction hose with strainer · Copper delivery pipes with brazed-on connections.

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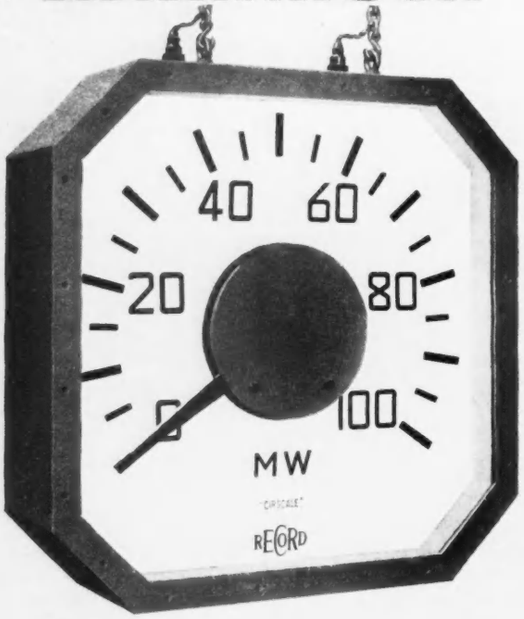
Mammoth



"Cirscale"

With a scale length of 5 feet, bold figures and internal illumination, this instrument can be read accurately at considerable distances. It complies fully with BSS 89/1954 and combines ample power with high sensitivity. It is suitable for indicating Amps, Milliamps, Volts, R.P.M. or Frequency, or any value which may be converted into one of these. Single or double sided models available

by RECORD

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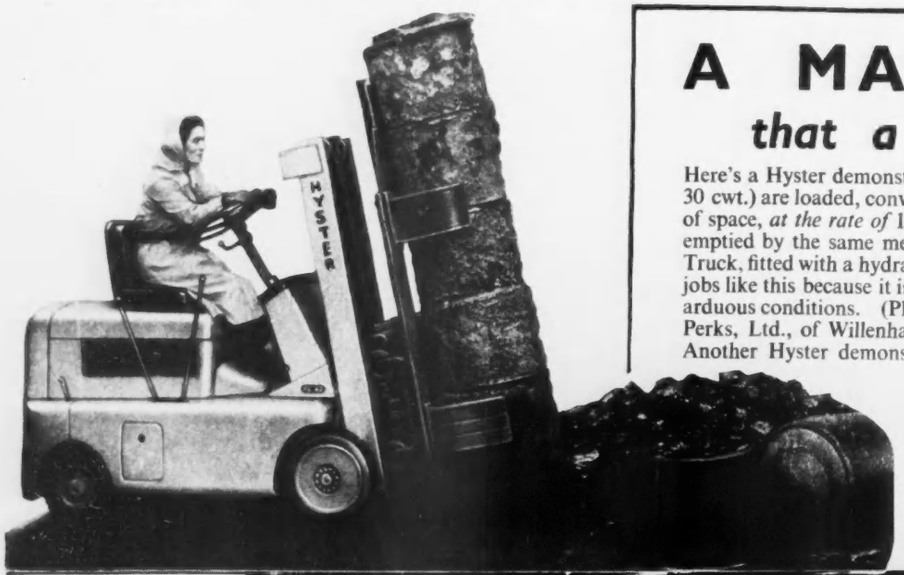
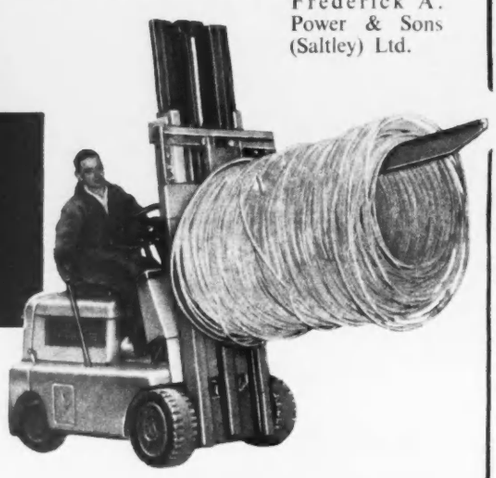


A MAN-SIZE JOB
that a woman can do

Here's a Hyster demonstration : Five filled annealing cans (gross weight 30 cwt.) are loaded, conveyed to furnace and neatly stacked without waste of space, *at the rate of* 125 *cans in under five hours.* The furnace can be emptied by the same method in *one hour.* The Hyster YC-40 Fork Lift Truck, fitted with a hydraulic load-grab with stabilising arms, can do heavy jobs like this because it is built to give unparalleled service under the most arduous conditions. (Photo shows Mrs. Winifred Birch of Messrs. Chas. Perks, Ltd., of Willenhall, Staffs, expertly handling the reliable Hyster.) Another Hyster demonstration : Here is the YC-40 Fork Lift Unit—sturdily built with rugged, steel-plate frame—transferring a 40 cwt. payload of steel wire from the acid pickling plant to the wire drawing machines at the works of Messrs. Frederick A. Power & Sons (Saltley) Ltd.



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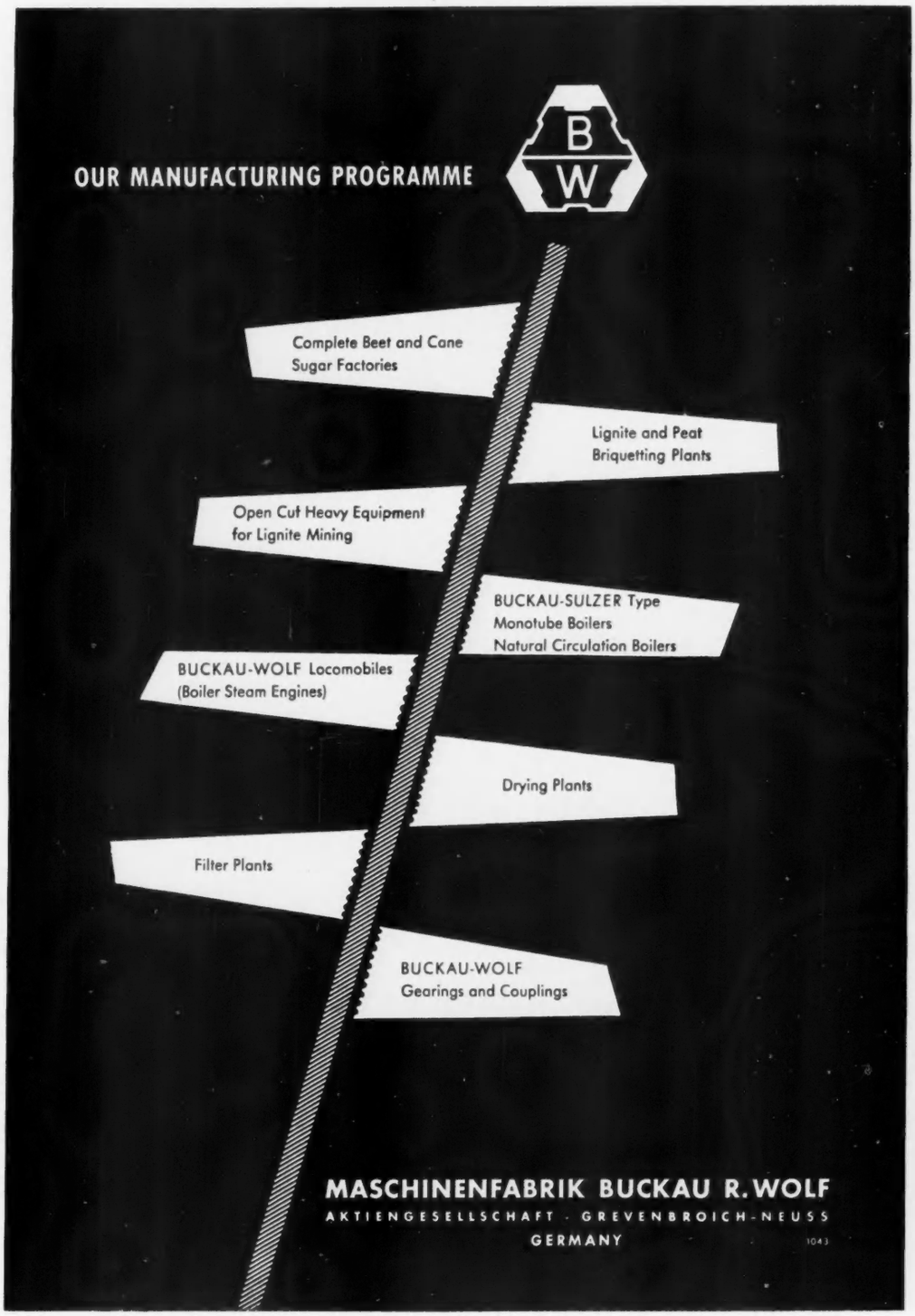
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The photograph shows part of an excavation in water-bearing sand, taken to 25 ft below standing water level. This work was carried out by a contractor who had not previously owned dewatering equipment, and without expert assistance.

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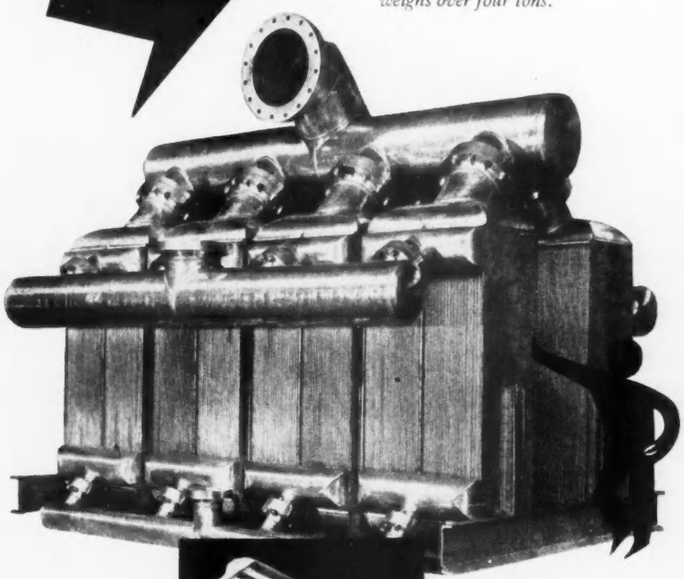

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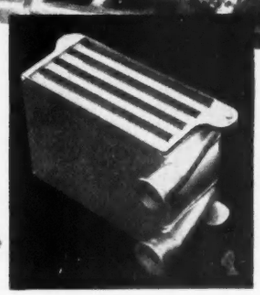

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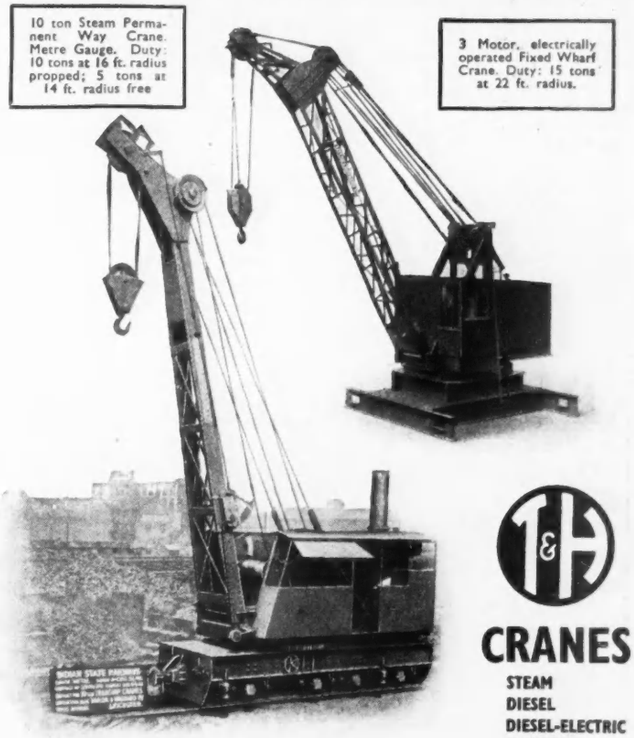

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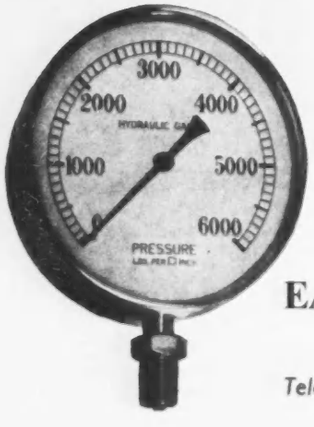

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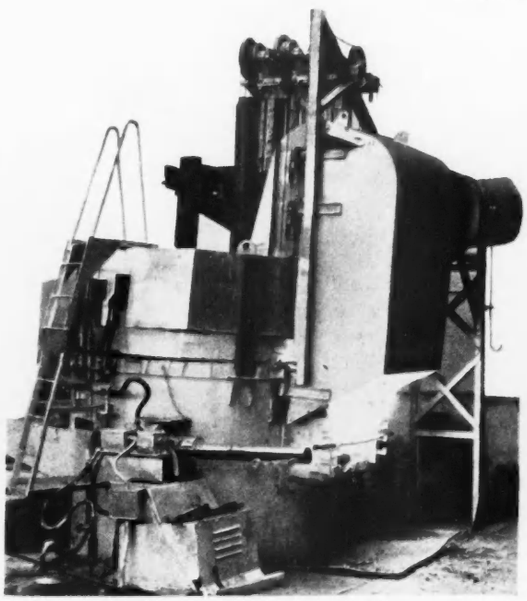

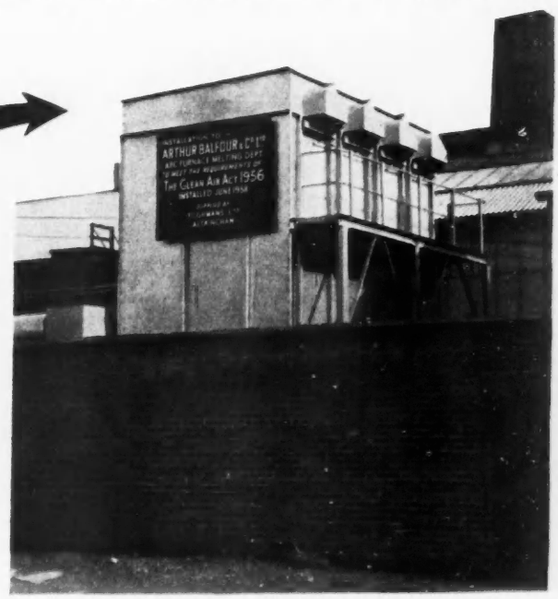

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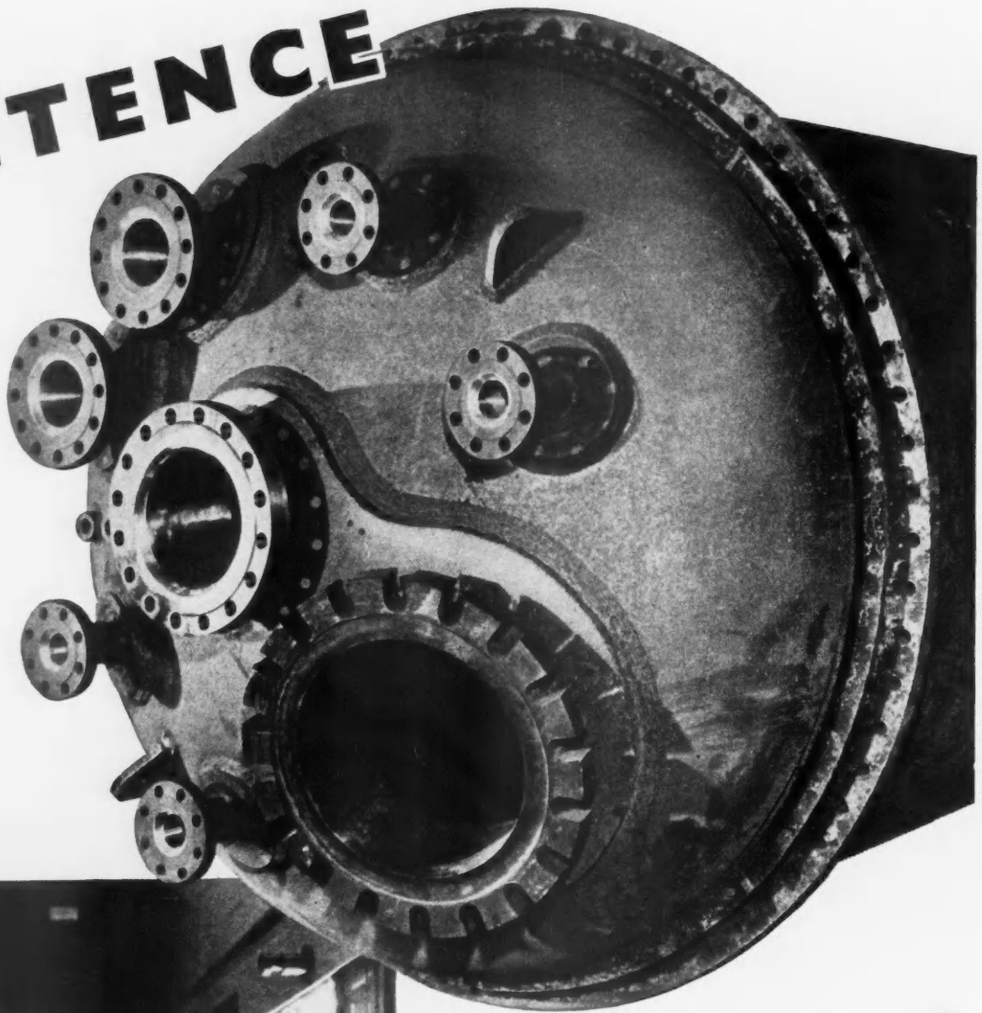

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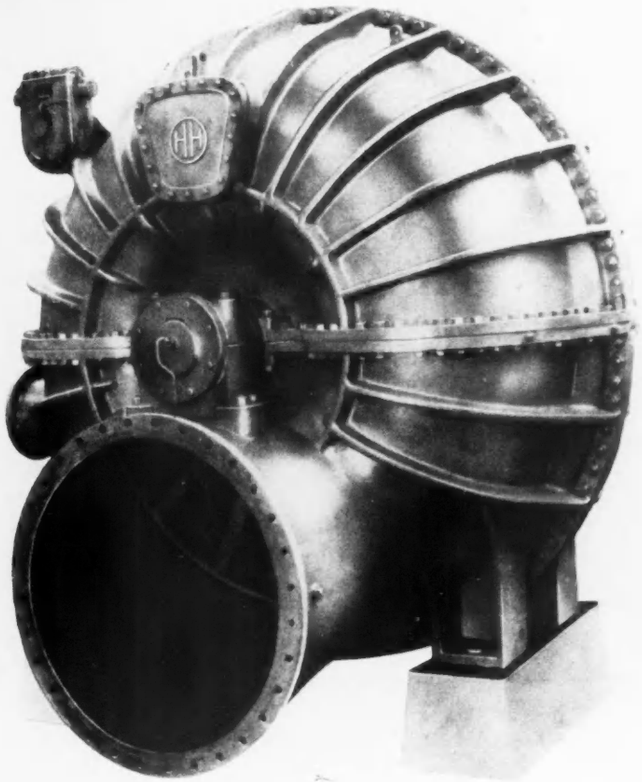

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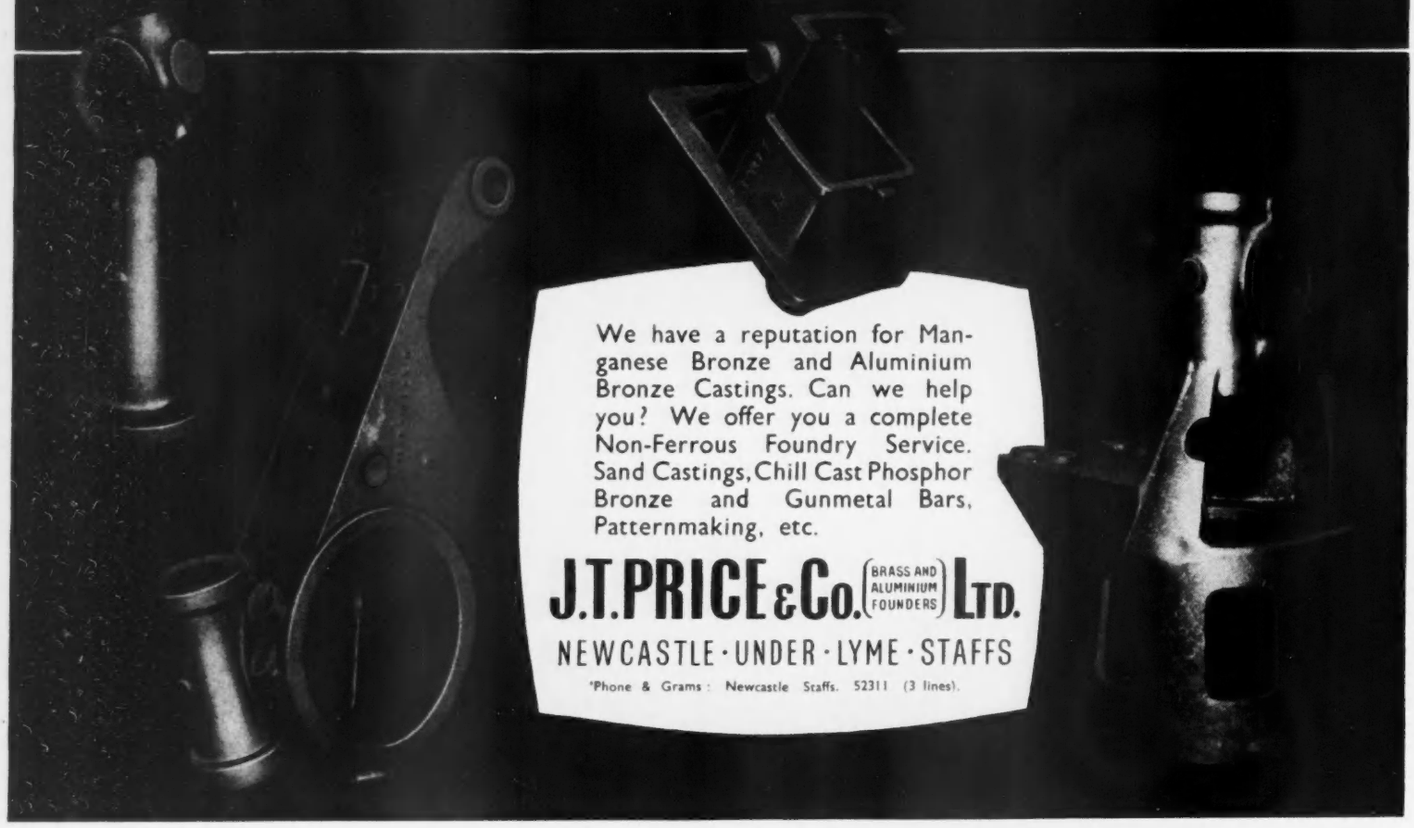

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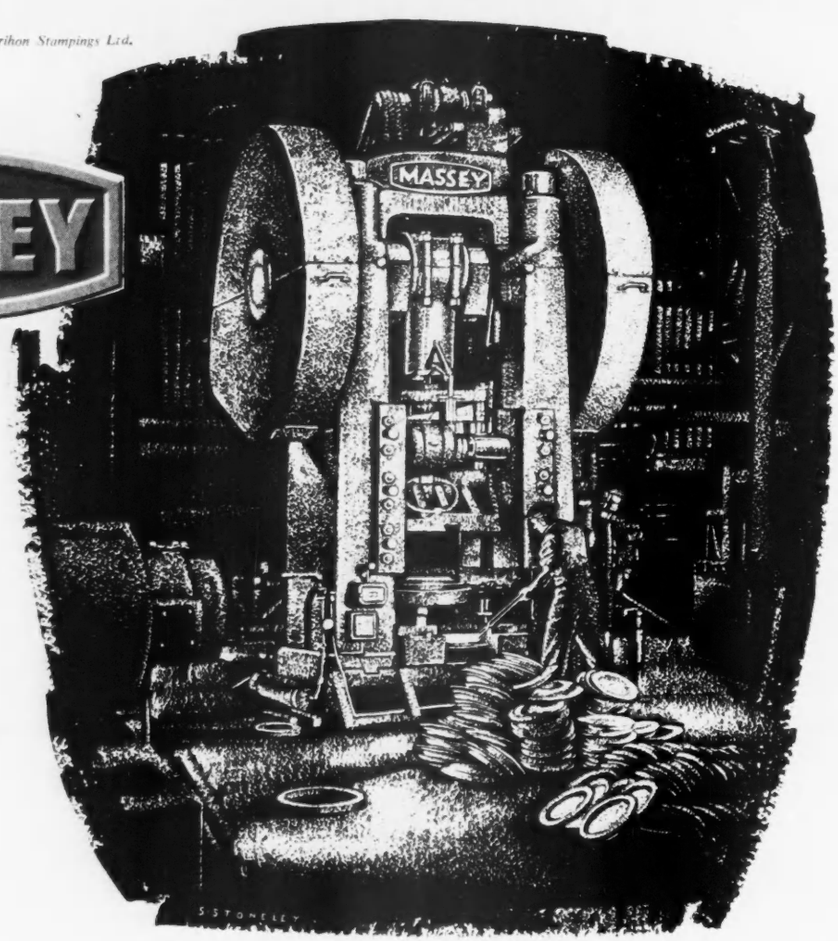

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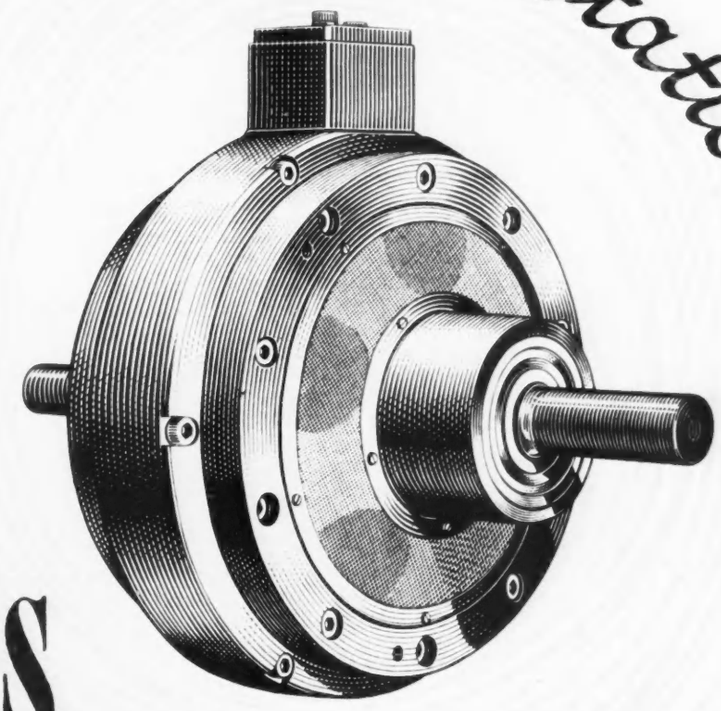

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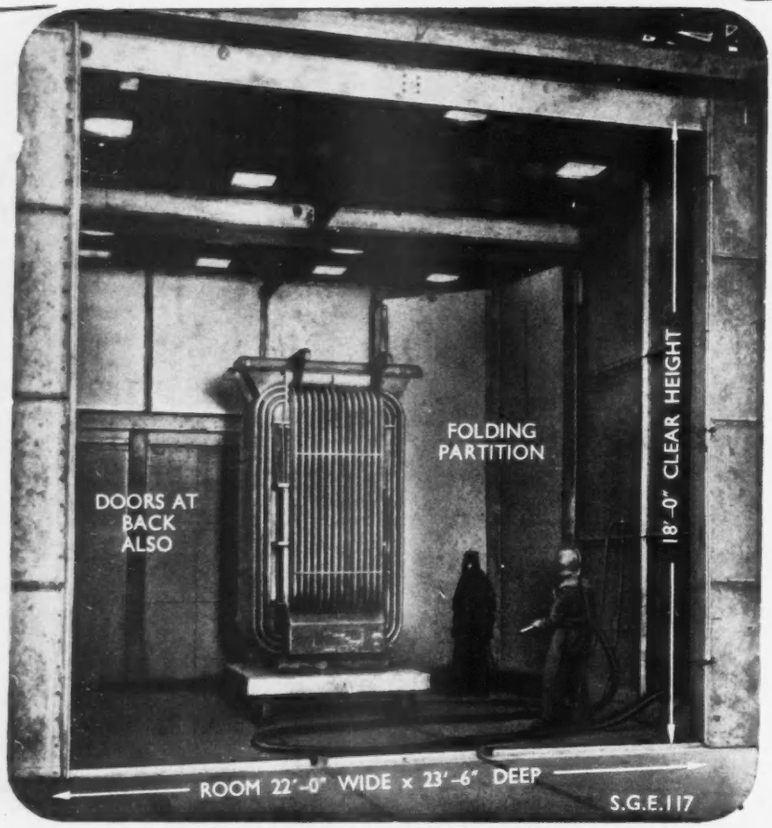

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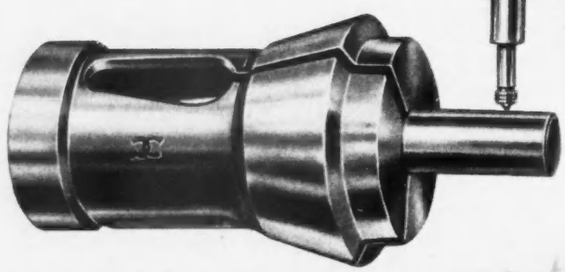

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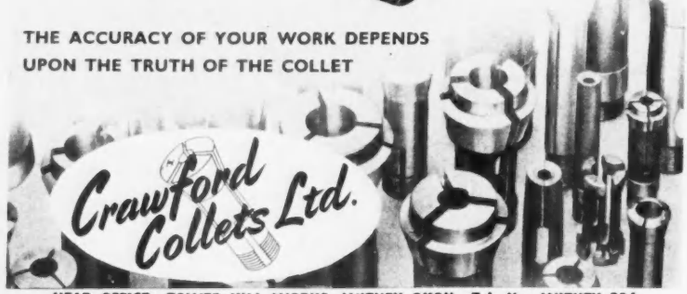

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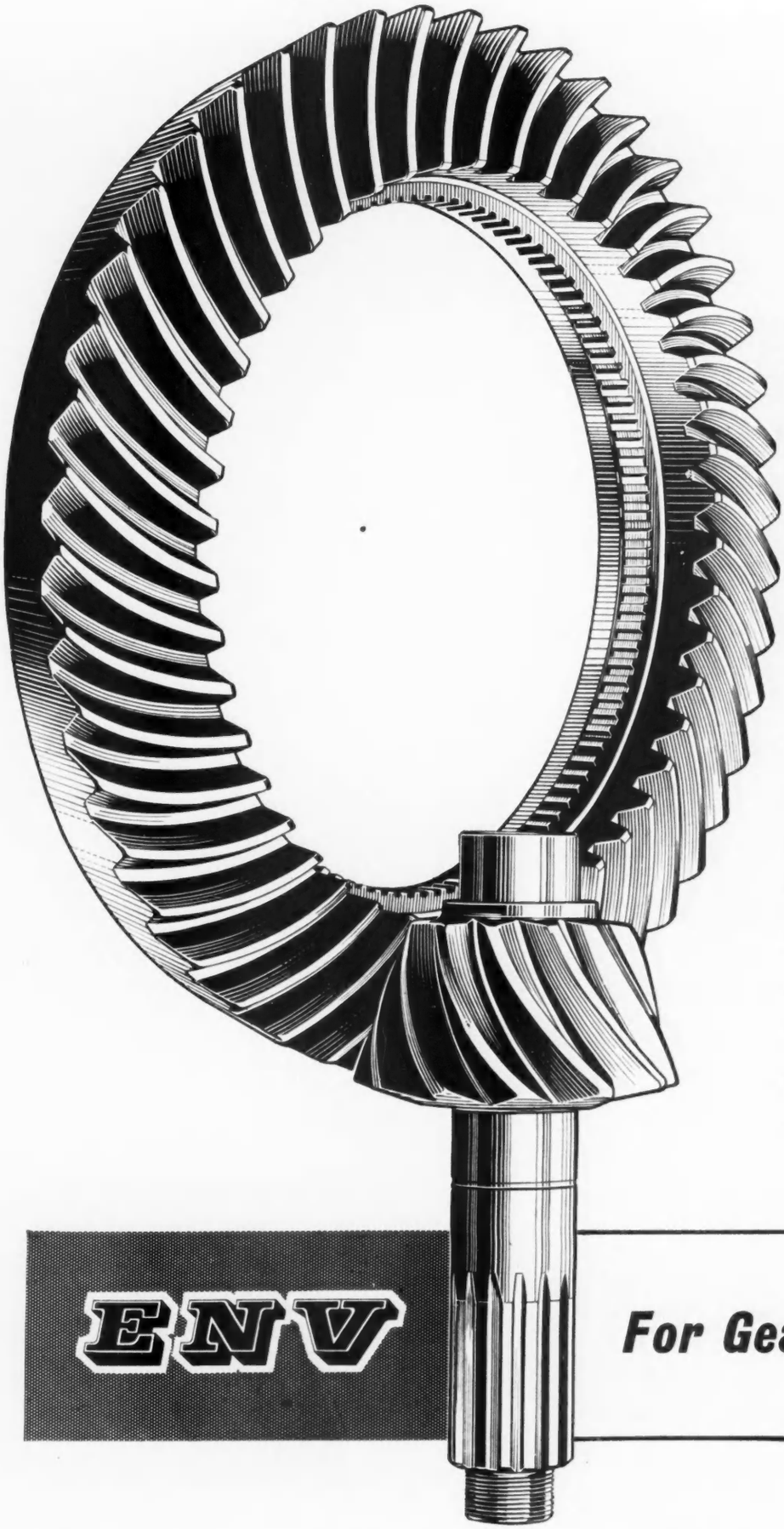

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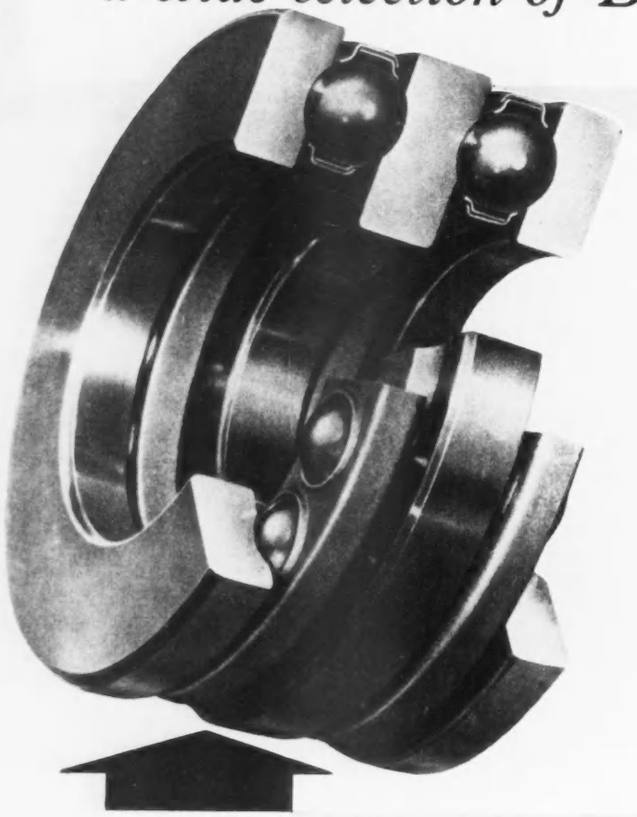

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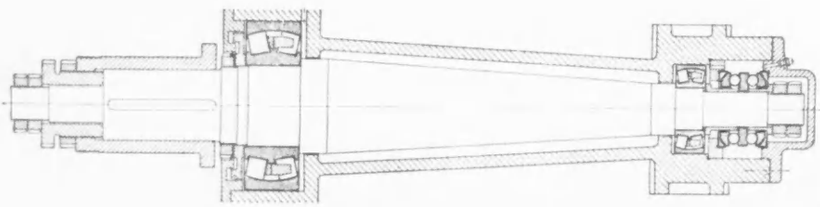
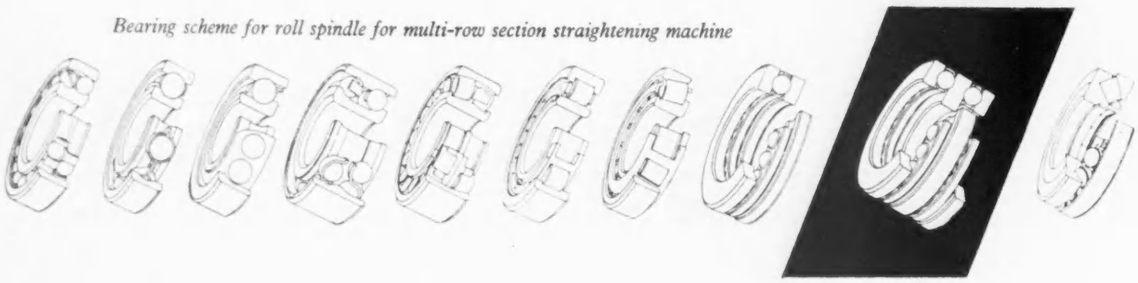


Bearing scheme for roll spindle for multi-row section straightening machine



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THE ENGINEER

No. 5368 DECEMBER 12, 1958 VOL. 206

TWILIGHT OR NEW DAWN FOR THE RAILWAYS?

In an address to a Sectional Meeting of the British Institute of Management last week Sir Reginald Wilson, Chairman of the Eastern Area Board of the British Transport Commission got off to a very bad start. It astonishes us profoundly that after all the road-rail discussion which has gone on for nearly forty years the propaganda department of British Railways (we cannot blame Sir Reginald) can put such remarks into its spokesmen's mouths as "In this country, given reasonable conditions, two men can move in one train as much as 25,000 ton-miles of heavy freight every hour or 40,000 passenger miles. No other technique yet known to us can touch such figures of output for land transport." It is not even good propaganda; for the road enthusiast is simply provided with a target which can be instantly and easily put down. Nor will any road haulage man be impressed by the perfectly true claim that a locomotive can haul half-a-million ton-miles per day; since, in fact, the claim has little relevance to the facts of ordinary railway working. Fortunately Sir Reginald soon afterwards threw the propaganda over the side and came rapidly down to earth again; and he was very soon introducing his audience to the much more real reasons why railwaymen have faith in the future of railways in this country. He outlined the provisions of the Modernisation Plan, making clearer than is sometimes the case, the fact that the Plan is not one for expanding the railways or one fitting them to do new tasks but essentially a belated one of replacement of obsolete or obsolescent equipment combined to some extent with a construction of the kinds of service provided.

The only criticism to be offered about all this was that every now and then there peeped out the railwaymen's continuing unfortunate conviction that road vehicles are incapable of carrying freight in bulk. To those, like ourselves, who wish the railways well it is quite frightening to find this misapprehension continuing to exist. The fact is that the capacity of a single road traffic lane to pass freight is certainly no less high than that of a single railway track and could well be higher, and there is nothing at all frightening about a convoy of lorries moving along at close intervals and at quite high speed provided the road is constructed to accommodate them. The railways neither have now, nor will have when modernisation has been completed, any monopoly in cheap and efficient bulk transport.

But by far the best part of Sir Reginald's address was that substantial section of it which dealt with changing policy. No doubt some of what he said was unwelcome to members of his audience. Yet, for ourselves, we feel impelled to say how encouraging it was to discover a railwayman thinking boldly and with sound common sense about traffics and charges and the attitude to customers that should be adopted. Even in this section we could still detect the existence of the railwaymen's misapprehension that railways are inherently better fitted for bulk transport than road vehicles. But it mattered little since Sir Reginald shared the clear recognition that whereas road vehicles can handle odd jobs economically railways cannot. It must therefore be the object of railways to encourage traders to give them regular predictable loads to convey and to discourage the offer of odd lots. If in their changing policies the railways follow out logically this line of thought some of the conclusions may prove, at least at first, unpalatable to industrialists. The industrial user, for example, will no longer be able to expect as confidently as at present to use his own "C" licensed road vehicles for the more regular work and depend upon the railways to carry the irregular peaks quite cheaply. But he may find the railways willing to quote very competitive rates provided he undertakes to assign regular loads to them. Furthermore, Sir Reginald recognises clearly that the alternative forms of land transport are not rail or road but rail-and-road or road. Railwaymen are convinced that, provided the railways can be rid of unsuitable traffics, and provided they can attract to themselves regular traffics, they will be able to show how advantageous combined rail-road carriage can be. If railwaymen in all departments are thinking about their problems as clearly and cold-bloodedly as Sir Reginald is his we should not be at all surprised to learn within three or four years that they are right.

TRUNK TELEPHONE DIALLING

As mentioned on page 937 of this issue, the first subscriber trunk dialling installation in this country was opened at the Bristol Central telephone exchange by Her Majesty the Queen last week. This event marks a major stage in the development of the British telephone service, for it means the beginning of the end of the operator as a means of establishing connection between one subscriber and another, however remote. In the British system a group routing and charging equipment known as "GRACE" interprets the code numbers and letters dialled by the subscriber, selects the route for the call (operating the switches at any exchanges on the way), determines the rate of charge for the call and, when the call is answered, controls the recording of the charge on the meter—doing automatically all the tasks that would otherwise be done by operators. In the first installation, any of the 18,000 subscribers connected to the Bristol Central exchange will be able to make trunk calls, simply by dialling, to more than half the subscribers in this country, including most of the main population centres. It is planned to extend this system of subscriber trunk dialling to include exchanges in forty-six other towns and cities by the end of 1961 and double that number a year later. According to present plans, it is anticipated that,

by 1970, more than three-quarters of all trunk calls will be subscriber dialled.

What these developments foreshadow, briefly, is a faster and more reliable telephone service at less cost. For example, it is stated that a dialled three-minute call from Bristol to London will cost 2s. 6d., compared with 3s. for a call connected by the operator. Viewed in isolation this prospect is wholly pleasing, but when it is studied against the background of the contemporary scene in other countries a very different impression is created. It is disturbing to discover, for example, that many European countries, as well as the United States and Canada, have already begun to replace operators by subscriber dialling systems of one kind or another for trunk calls and that some of them have gone a considerable way towards complete changeover. In Federal Germany, for example, more than two-thirds of all the trunk calls are already being dialled by subscribers and this proportion is not likely to be reached in Great Britain within the next ten years ! In France, which has fewer telephones per head of population than has Great Britain, a quarter of the total trunk traffic is automatically dialled. In Sweden, where there are more telephones per head than in this country, approximately half the trunk calls are so dialled. Such comparisons can, of course, be misleading unless due allowance is made for all the relevant circumstances, including densities of population, distances between main population centres, standards of living, and so on. But none of these considerations can explain why it is that Britain should have been comparatively so slow in pursuing so promising a line of progress. This tardiness cannot be attributed to technical backwardness amongst British telephone engineers. On the contrary, both in the G.P.O. and in the manufacturing industry which works so closely with it, the ability and zeal of British engineers responsible for research, design and execution are second to none. The responsibility clearly rests with the unfortunate policy of Government restrictions upon capital expenditure. We touched on this matter in a leading article in our issue of June 20, 1958, when we suggested that cuts of about £5,000,000 and £10,000,000 in the Post Office estimates for the years 1958–59 and 1959–60, respectively, tended to make a " lagging network " of the country's public telephone system. We repeat that these cuts are deplorable, whether they hamper the growth of automatic dialling or whether they merely retard the rate at which new subscribers can be connected. The economies are miserable and illusory. They defeat the more laudable aim which should be to intensify the introduction of automatic dialling everywhere, which would reduce the cost of trunk calls and, therefore, encourage increased traffic and produce increased revenue. What is equally important, it would enable the Post Office to give its subscribers an unrivalled telephone service.

COAL

On Wednesday of last week, the House of Commons debated coal. The debate was a useful one for it did at least help to clarify what to many people is a confused situation. The debate was on a Government motion seeking approval to extend the borrowing power of the National Coal Board. The approval was given and the Board may now borrow up to £130 million (instead of £75,000,000) of " what it is authorised to take in any one year " without asking the sanction of Parliament. The debate was opened by Sir Ian Horobin, Parliamentary Secretary to the Ministry of Power, who was careful to explain that the extension of the Board's borrowing powers was in no way concerned with deficit financing. He recalled that the coal industry began this year with an accumulated deficit of approximately £30,000,000 and he obviously considered it encouraging that, owing mainly to an income tax windfall, the revenue loss for 1958 was likely to be much the same as last year's, namely, of the order of £5,000,000. But, as is well known, there are large undistributed stocks of coal in this country which cannot, at present, be turned into money. The Coal Board's view is that these stocks are an extremely valuable asset. It is a view which is endorsed by the Ministry of Power, though it cannot be overlooked that the maintenance of this " valuable asset " is costing a lot of money. The Coal Board has estimated that, by the end of the year, that is in three weeks' time, unsold stocks are likely to be of the order of 19,000,000 tons, mostly of small coal. The Board adds that this coal is not unsaleable ; that may well be the case. But it must be realised that the existing demand is far from brisk and the Board acknowledges, a little belatedly perhaps, that stocks " are fast approaching the limits, both in space and finance." Earlier this year, it became evident that a speedy revival of coal demand could not be anticipated and various economy measures were introduced by the Board, with the cognisance and support of the National Union of Mineworkers. Those measures have achieved something but obviously not enough. According to the Board's latest assessment, this year's coal production will turn out to be 10,000,000 tons or so above the total amount sold at home and overseas. Undoubtedly, it is prudent to have reasonable stocks in hand, but there is no economic virtue in continuing to build up an unwanted surplus.

The National Coal Board has, therefore, quite understandably prepared an output plan for next year. It discussed the details of this plan with the National Union of Mineworkers and published them on the same day as the debate in Parliament. They are reported on page 940. The plan, which the Board and the union are discussing again to-day, provides for opencast coal output to be reduced by 3,000,000 tons and deep-mined production by a similar amount. This latter reduction, it is stated, is to be effected by the ordered closing of a number of highly uneconomic pits and by a closer concentration of working. It is indeed an unexpected anomaly that, whereas three years ago it was necessary to import over 11,000,000 tons of coal to keep the wheels of industry turning and the home fires burning, the coal industry is now financially embarrassed by the overproduction of this country's traditionally valuable mineral ! Meanwhile, the Coal Board's capital investment programme continues and it is expedient, of course, that it should do so. Mine modernisation projects are essential but they require years, rather than months, for completion ; the overall plan for coal must, therefore, be flexible, as the Board itself has said many a time. But modernisation projects are valuable only if they result in more efficient and, consequently, more economic production. One encouraging fact brought to light during the Commons debate is that, recently, deep-mined coal output per manshift has been at a record figure of 26 cwt. The miners' wage increase which has now been granted, without the conditions specified by the Board a few weeks ago, may serve as some incentive to the maintenance of that improved productivity. Parliament has given its approval to the proposal for extending the Coal Board's borrowing powers ; it could really do no

other. But unless the coal industry's production costs can be held and ultimately reduced, there is not much hope of any lasting improvement in its financial condition.

FIRST WORDS AND LAST

In his Anniversary Address to the Royal Society on December 1 Sir Cyril Hinshelwood opened with the words " If, as some of us believe, natural science is to-day the foremost of humane studies . . . ." He closed the Address with the words " It is all too easy to think of detailed and absorbing work as an end in itself, but in so far as we may yield to the temptation science will fail to occupy that place in the scheme of things which is its rightful due." Those are words that could be taken to apply even more appropriately to engineering than to science. For the complete study of any engineering subject must bring the man concerned into contact with human beings both as makers of some engineering device or as its users ; and though it is very easy for engineers to bury themselves in their work they do not, we think, benefit the human race in that way as much as by studying the broader implications of all that they do. Of course, Sir Cyril's opening words will be rejected as false by those who obstinately cling to the idea that one can be broadly educated without any knowledge of science whatever. It is, indeed, astonishing that science should still be regarded by some educated men as an inhuman subject when one considers that it throws light upon the mysteries of the origins of man and nature and that in its practice the scientist has to discipline himself to an immense respect for truth, a respect that he undoubtedly carries over into the practices of his ordinary non-scientific life.

It is, we suggest, the fact that it is so fatally easy " to think of detailed and absorbing work " in engineering as well as in science " as an end in itself " which permits that idea to persist. For in the minds of laymen scientists and engineers are often " back-room boys " living in a special world of their own creation which nobody else can understand. We applaud therefore Sir Cyril's final words. It is, we believe, desirable for the prosperity and peace of the world that a greater proportion of engineers and scientists should " occupy that place in the scheme of things " which is their due.

THE FIRST EIGHT MILES

On another page of this issue we describe the Preston by-pass, which is the first example in this country of a modern high-speed motorway. The by-pass is only $8\frac{1}{4}$ miles in length, so it cannot be held to have any national significance, in itself, in the supersession of the out-dated and hazardous roads of this country. However, its inauguration is a welcome event, rather as a portent of the benefits which such roads will bring in the future, than as an accomplishment. The Ministry of Transport and Civil Aviation has 380 miles of motorways in its " present road programme." The first sizeable length of motor road will be the London/Birmingham stretch, which is due to be opened next autumn. Then, we think, the benefits which these roads bring will really begin to be appreciated, though interest has quickened noticeably over the past week.

One or two facts may, perhaps, be quoted to bring into relief the effect of this one, almost infinitesimal, golden thread in the tangled skein of British roads. The " design speed " is 70 m.p.h., the number of access points is two over the total length, as compared with 1898 on the shorter route which the by-pass supersedes. The accident rate per 1,000,000 vehicle-miles is 5·8 on the old road, and it is estimated that it will be about 0·4 on the new road ; journey times will be one-half to one-eighth of their values on the old route. Though costing over £3,000,000, the road will prove to be a sound and remunerative investment in reducing transport costs and accidents.

But its full benefits cannot be felt until it is linked up in a more comprehensive motor road network, as envisaged in the county surveyor and bridgemaster Mr. Drake's road plan for Lancashire, published nearly ten years ago, and, indeed, as envisaged by Lancashire County Council in 1937 when the North–South motorway was conceived. Even so, the completion of this prototype of British motorways by Mr. Drake and the engineering staff of Lancashire County Council " without recourse to outside technical assistance " (save, of course, collaboration with the Ministry's engineers) is a notable feat. It points to a healthy renaissance in British highway engineering, which we can only hope will grow rapidly in volume and in merit.

The Engineer—100 Years Ago (DECEMBER 10, 1858)

" METROPOLITAN RAILWAYS "

" A public meeting, in which the wealth and respectability of the metropolis was fully represented, has formally resolved that the present crowded condition of the principal thoroughfares of London is injurious to trade and that the crowded state of the dwellings of the poor is one of the most serious of the social evils of the day. To this extent the meeting has merely given public expression to the opinion not only of bustling tradesmen, impatient passengers, and philanthropists in general, but of all indeed who are accustomed to apply the first considerations of social economy to the internal arrangements of extensive communities. As to the means by which the evils mentioned are to be avoided, the meeting was further of the opinion that a sub-way railroad, intersecting the metropolis, promised much relief, and that renewed efforts should be made to complete the subscriptions required for the construction of the Metropolitan Railway . . . . .

" The Metropolitan Railway, by which it is proposed to relieve the overcrowding of the principal streets of London, is to be a tunnel extending from Victoria-street under the Fleet Valley to King's-cross, and thence, as we understand, under the New-road to Paddington—a distance in all of nearly four miles . . . The cost of the Metropolitan Railway is estimated at £950,000 of which £300,000 are understood to have been already subscribed by individuals, and £175,000 more by the Great Western Railway Company, leaving £475,000 to be secured by further subscriptions. The Great Northern Railway Company, which has been solicited to subscribe £175,000 to the scheme, has refused. Should means be secured to make the railway, it is questionable, at least, if it would pay. Of the present class of passengers upon the Great Western Railway, but a very few could be expected to come to Victoria-street, nor is it probable, looking to the removal of the poorer classes into the suburbs of London, that those contiguous to the West-end would be selected. To reach the Great Northern Line, the proposed railway might better be made above ground up the Fleet Valley, for it is not probable that the public would prefer a subterranean passage where there is room for one in open daylight. A subway can never be popular as the channel of an extensive passenger traffic."

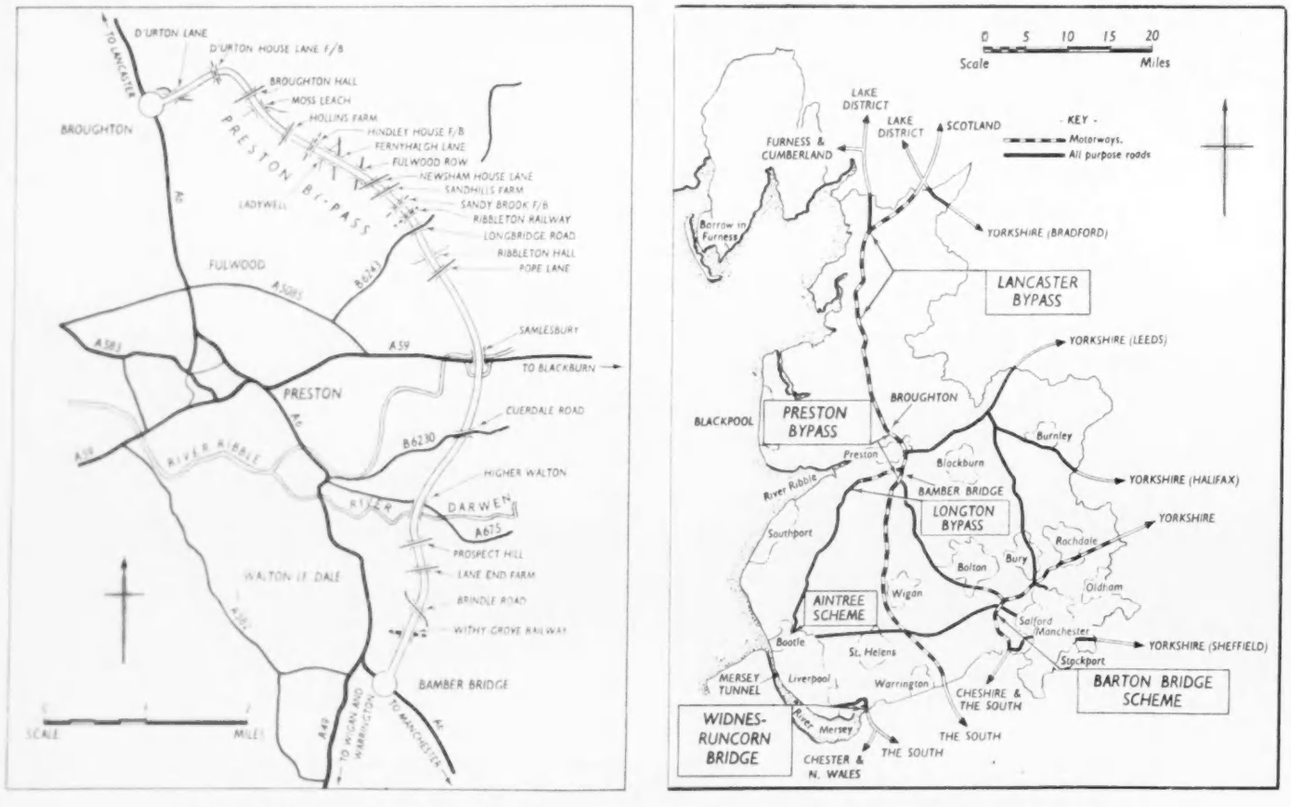
Opening of the Preston By-pass Motorway

Last Friday the Preston by-pass motorway was opened by the Prime Minister, Mr. H. Macmillan. The by-pass is 8¼ miles in length, and will eventually form part of Lancashire's North–South motorway. Its inauguration is of special significance, since it is the first road in the British Isles for motor traffic only, being designed to full motorway standards. The accompanying illustration shows the view southwards along the road from Broughton Hall bridge.

BRITAIN'S first stretch of motorway, the 8¼-mile Preston by-pass, was inaugurated a week ago to-day. Apart from full motorway standards in its design, and, correspondingly, its use by motor traffic only, the road is of special interest as an achievement in civil engineering construction. This aspect of its design has also been as modern in concept as the traffic aspect, and sets out to take the maximum advantage of mechanised constructional methods. Heavy earthworks have been involved, and many bridges have been built. The road itself utilises machine-laid "premixed" water-bound macadam in the carriageways, as developed by the Lancashire County Council's engineering staff, and its basic design originated from extensive soil testing.

The road has been described as a "guinea pig"; motorway traffic signs, the efficacy of the motorway code, drivers' reactions and opinions, the necessity for speed limits, and the presence of abnormal loads are amongst the factors which will be discussed as experience of its use is gained. The Ministry of Transport and Civil Aviation will then be guided by this experience before the opening next autumn of the first major length of British motorway, the London to Birmingham route. In the ensuing paragraphs, these matters are not discussed, and in our description we have concentrated on the civil engineering works involved. The accompanying diagrams show the route of the by-pass and its various bridges in detail, and its relationship to the network of motor roads planned, or under construction, in Lancashire. Its 8¼-mile route commences at a point on the Manchester–Chorley–Preston trunk road A.6 approximately 550 yards south-east of its junction with the Warrington–Wigan–Preston trunk road A.49, passing east of Bamber Bridge to cross the River Ribble at Samlesbury about 600 yards east of Brockholes Bridge, thence by-passing Preston on the north-easterly side and terminating at the Preston–Lancaster–Carlisle trunk road A.6, 190 yards south of D'Urton Lane at Broughton. The last mile will deviate from the line of the proposed North–South motorway, into which the rest of the road will eventually be incorporated. This length is the future north link to Preston as well as forming part of the future Blackpool motorway and has been built at this stage to complete the by-passing of Preston.

The various photographs reproduced with this article give a good idea of the appearance of the new by-pass as it was when almost completed. It has dual 24ft carriageways, which may each be widened to 36ft later on, with a central reservation, 1ft contrasting marginal strips and hard shoulders, all of which is explained in detail below. The junctions at each end of the road are surface roundabouts, which will eventually be modified to form two-level junctions in the comprehensive motorway scheme, and another additional junction may also be added.



The Preston by-pass motorway, showing its bridgeworks and its relation to other motor roads projected in Lancashire

There is a U-shaped grade-separated junction at Samlesbury by the River Ribble, which is at present the only intermediate point at which access to the road may be gained.

Road Layout

In general the overall width of the by-pass is 112ft with dual carriageways 24ft wide. A contrasting marginal strip 1ft wide (the strip is of concrete, and the carriageway is "black top") flanks each carriageway, so the effective width is 26ft. The outer verges are 14ft wide, including an 8ft width constructed to form a hard shoulder abutting on to the carriageway. The central reservation is 32ft wide, so ultimate widening from two-lane to three-lane carriageways will still leave a reservation 12ft wide. The three-lane road will be needed, it is considered, for carrying the estimated ultimate traffic capacity of 46,000 vehicles daily. Continuous steel fenders are put outside the hard shoulders on all embankments higher than 20ft, on the straight, and 10ft on right-hand curves.

The design speed of the motorway is 70 m.p.h. The minimum radius of curvature is 3015 yards, and the maximum gradient 1 in 25. The maximum length of straight road is 1000 yards. All these figures generally follow quite closely the Ministry of Transport's recommended standards, though there are some minor differences. In addition, horizontal and vertical alignments have been co-ordinated with the aim of giving a pleasing effect in the landscape. The Ministry's standards are, in fact, as follows :

Straights, minimum 400 yards, maximum 1000 yards ; minimum sight line, 650ft ; minimum radius of horizontal curves, 2 deg. (2865ft radius) ; maximum gradient, 3½ per cent normal with up to 5 per cent in hilly country.

Curves of a shorter radius than 5730ft (1 deg.) are approached at each end by a transition curve, the length of the spiral being such that the rate of change of centripetal acceleration does not exceed 1ft per second per second per second. The design speed of 70 m.p.h. for super-elevations is in general developed uniformly along the length of the spiral.

The use of contrasting marginal strips as a "haunch" to the edges of the carriageway, instead of kerbs, has enabled vertical curves of very large radius to be employed, drainage gradients being unimportant as all surface water flows off the side.

Although a hard shoulder is provided for emergency use it is not intended to encourage parking along the side verges, other than at established lay-bys, sited at approximately 1 mile intervals along the road.

To economise on bridge construction, the width of the side verges at bridges with spans or widths greater than 20ft has been reduced to 4ft, plus a 1ft marginal strip. To prevent vehicles from running on to the verges at these spots there is a 6in by 12in concrete kerb for a distance of 175ft before and 75ft after the bridge.

On embankments the general overall width is increased to 118ft between tops of slopes to allow for the planting of quickthorn hedges.

The terminal junctions of the by-pass with the existing road system are surface roundabouts with a minimum diameter of 240ft. These will ultimately form two-level junctions when the motorway is continued southwards to Cheshire, and the Broughton link continued through as a motorway to Blackpool.

Samlesbury Bridge carries the motorway over the River Ribble and the trunk road A.59. The deck consists of continuous box girders with curved soffits, the roadway being carried on a reinforced concrete deck slab

At Samlesbury the junction with the Preston–Whalley trunk road A.59 presented a problem in that the "ramps" had to be wholly on one side of the trunk road owing to the proximity of the River Ribble ; the design here is in the form of a U-junction, with roundabouts of 180ft diameter on the trunk road. The trunk road and the river are parallel, and the motorway bridges over them, along the centre line of the "U," the arms of which are formed by the slip roads connecting the two roundabouts and the motorway, as can be seen in the illustration on page 917. The junctions are characterised by acceleration and deceleration lanes.

All these features, and the general standard which they imply, conform fairly closely to the Ministry's requirements, which, it can be expected, will be followed fairly closely in all motorway construction. But since the Preston by-pass is the British prototype, it may be of interest to point out the enormous advantages which these standards bring, by comparing the old and the new routes. This is done in Table I ; the comparison of access points and accident rates is especially striking.

Table I—*Comparison Between the New By-Pass and the Existing Route*

	North-South Motorway (Preston by-pass)	Existing route
Minimum width	112ft	31ft
Minimum radius	3015ft	50ft
Maximum gradient	1 : 25	1 : 14
30 m.p.h. speed limit	Nil	97 per cent
Length	(i) Excluding north link to A.6 7·26 miles (ii) Including north link to A.6 8·26 miles	6·76 miles
Access points	2	1898
Estimated car travelling time	8 to 12 minutes	17 to 90 minutes
Accident rate per million vehicle miles	0·40 (estimated)	5·80 (actual)

Casualties between April, 1946, and April, 1956, on the existing route proposed to be by-passed totalled 1170.

Carriageway Design

Design was based on the results of extensive soil surveys. Borings were carried out by the county highways laboratory. The soils encountered were predominantly clays, with wet sand and silt veins occurring at the deep

The motorway, looking south from the north escarpment of the Ribble Valley

cuttings. Percussion rigs, equipped with a power-operated winch and capable of drilling 5in and 6in diameter bores to a depth of 100ft, were used for boring. Boreholes were made at approximately 200 yard intervals in both cut and fill areas. Normally, four additional boreholes were taken at each bridge site. Undisturbed soil samples were obtained from each borehole in 4in diameter tubes 1ft 6in long.

All soil tests were carried out at the county highways laboratory, which carries a full range of soil testing equipment. The *in situ* wet and dry density and shear strength of the soil were obtained from the undisturbed samples. The unconfined compression test was carried out on clays to obtain the shear strength and the triaxial test was used for sands and sandy clays. Other tests included classification of the soil, determination of liquid and plastic limits and particle size analysis. From all the soil test data the depth of construction of the carriageways and the design of safe slopes for cut and fill areas were determined. The site investigation involved a total of 199 boreholes with a total depth bored of 5150ft.

The carriageways are of flexible construction, designed to the 20,000 lb wheel load curve to the Ministry's specifications. As mentioned above, the soils along the route are chiefly clays, and the depth of construction depended on the C.B.R. values of the subgrade, determined during construction. The thickness of the sub-base was varied to obtain the required construction depth. The exceptionally heavy loads and weak clays necessitated in places a deeper construction than normal. For the greater part of the sub-base, a local waste product, burnt colliery shale, was used. Its depth varied from 12in to 36in.

This sub-base was covered by a 9in thickness of premixed waterbound macadam, followed by a 2½in tarmacadam base course, with a ¾in cold asphalt surface in which were embedded precoated granite chippings. The final course, after settlement of the road has taken place, will be a rolled asphalt wearing coat. The whole of this construction has been effected mechanically, and it utilises local materials. The premixed waterbound macadam, developed by the county council, is considered to have proved satisfactory.

The hard shoulders consist of a minimum compacted thickness of 4½in of gravel, topped with a 4¾in compacted thickness of a mixture of stone, sand and loam; the shoulders are sown with grass and merge with the verges.

Earthworks and Drainage

Surface water from the carriageways and hard shoulders is collected by cast *in situ* concrete drainage channels sited along the outer edges of the "hard shoulder," or on super-elevated sections of the by-pass in the central island and the outer edge of the hard shoulder on the low side. From these channels water enters the general water drainage system running along the road and discharges into existing water courses at selected points.

Where the road is in a deep cutting, the concrete drainage channels are replaced by French drains, which also collect the face drainage of the slopes. In certain very deep cuttings, such as the north escarpment of the River Ribble, the French drains in the side verges have been increased in dimension to act as shoulder drains at the base of the banks, and will form a support as well as collecting water from the deep face drains and herringbone drains provided to strengthen the slopes.

Catch pits have been provided along the lines of the concrete drainage channels, enabling the surface water drain to be laid in the verges at a shallower depth than with the normal type of gulley.

Preliminary work in setting out and proving the centre line and clearing the site involved felling 1500 trees, removing 10,000 yards of hedges and erecting 30,000 yards of temporary fencing. Other equally essential preparatory work involved the "pre-earthworks" drainage works needed to deal with the many ditches, streams and other water-courses crossing the by-pass, many of which were converted to pipe or box culverts ranging from 9in diameter earthenware pipes to 9ft by 9ft box culverts. In addition, long lengths of storm water drains, which will form part of the main by-pass drainage system, have been constructed.

The construction of the by-pass also required the alteration or diversion of seventy-eight statutory undertakers' services, including several important trunk mains.

Earthworks for the construction of the by-pass have been heavy, as is shown by the figure in Table II (which also lists quantities for the bridgeworks). Excavation was carried out to the extent of 2,250,000 cubic yards. The maximum depth of cutting was 62ft and the maximum height of embankment 56ft.

To deal with the heavy earth-moving programme, the contractor assembled at the start, in June, 1956, a fleet of heavy plant which included tractors, scrapers, large capacity excavators, and rear dump trucks, but the heavy rains of the autumn of 1956 made it virtually impossible to work the sandy clay sub-soil and so the heavy earth-moving was postponed until the following spring (1957) and the contractor was granted a five-months' extension of contract.

On reassembling the heavy plant, there was a welcome respite from the rains, and over the ensuing fine period of some twelve weeks intensive work enabled about 50 per cent of the excavations to be completed. Then the previous year's experience repeated itself and, until a brief fine spell in the spring of 1958, ground conditions made it possible for earth moving to proceed only at a fraction of the desired rate. Nevertheless, the contractor used every means available to overcome the physical difficulties, with the result that the works have been completed within the revised contract period of two years five months.

In order, however, for this to be accomplished, it was found necessary to authorise the running to tip of large quantities of excavation of which, had weather conditions permitted, much could have been used for embankment construction, and this tipped material had to be replaced by imported material. The problems arising from the incessant rains were many and varied, one instance being the deep cutting through the south escarpment of the Ribble, where it was found necessary to redesign a portion of the eastern slope. It was also found necessary to remove an unsuspected peat bog in the Ribble Valley.

The contractor's original plans were based on examination of weather records over eighty years. The conclusion was reached that March, April, May and June—a total of sixteen weeks—were the only months that could be relied upon to be fine. Accordingly, sufficient plant was arranged to carry out most of the earth-moving in that period. But, as already noted, much of the spoil removed from cuttings at the start of the season was found unsuitable for use in embankments. In some cuttings considerable quantities of lump stone had to be punched into the silt to make a stable base for carriageway construction.

Bridgeworks

Twenty-two bridges are built over or under the motorway, as follows: two carry the motorway over both a river and a road; six carry the motorway over roads and streams; six carry roads over the motorway; one carries the motorway over a railway; one carries a railway over the motorway; and six carry "occupation" roads and footpaths over the motorway.

Broughton Hall bridge carries a Class III road over the motorway, the spans being 36ft 6in, 49ft, 49ft and 36ft 6in. The width of the bridge is 34ft, piers and abutments are on concrete piles and the deck is of precast prestressed concrete beams

TABLE II—*Constructional Quantities*

Excavation	3,400,000 tons
Imported filling	668,000 tons
Ashes	176,000 tons
Red shale underbed	288,000 tons
Premixed waterbound macadam	120,000 tons
Tarmacadam base coat	31,000 tons
Cold asphalt surfacing	12,000 tons
Drains and sewers	55,000 yards
Concrete	35,000 cubic yards
Reinforcing steel	950 tons
Structural steel	2,900 tons
High tensile prestressing wire	220 miles
Piling in bridge foundations	21,000 lineal feet

The Preston by-pass motorway at the junction with the Preston-Whalley road. At this point the motorway crosses the River Ribble and sweeps away to the northward

The cost of the bridgeworks is about a third of the total.

The main bridges are designed for Ministry of Transport standard loading, including the abnormal indivisible load—180 tons on four axles—for the motorway bridges.

The two principal bridges are (*a*) at Samlesbury, over the River Ribble and trunk road A.59—a three-span continuous steel girder bridge of spans 120ft, 180ft and 120ft, giving a total length of 420ft between abutments which, together with the piers, are stone faced, and (*b*) at Higher Walton over the River Darwen and county road A.675, a multi-span continuous steel girder bridge carried on concrete trestles with four main spans of 97ft 6in each and two end spans of 42ft 9in, an overall length of 474ft.

The remaining bridges are of single, three and four spans, twelve of them having prestressed concrete decks and three having decks of steel girder construction. Five, comprising two footbridges and three large culverts, are of reinforced concrete. In five cases ground conditions necessitated piled foundations.

A statutory headroom of 16ft 6in has to be provided at all bridges so a headroom of 17ft has been allowed, the additional 6in being for any slight settlement of the bridge during and after construction and for the re-surfacing of the roads under the bridges.

For overbridges four-span structures have usually been adopted as this gives a minimum depth of construction and is therefore generally more economical, particularly in those cases where the road being taken over the motorway has to be raised on embankment to make the crossing. There were, however, certain conditions under which it was considered advisable to adopt alternatives to the four-span. For example, where the motorway is on a curve a pier in the central reservation may interfere with the sight lines of the traffic, and in these cases a single span has been adopted. In another case, at Pope Lane, the motorway is in deep cutting and here a three-span bridge has been built.

For the underbridges, single spans have normally been used. The occupation bridges, all of which are over the motorway, are of four-span construction.

In both prestressed and steel construction, where a reinforced concrete slab is supported by beams, composite construction was allowed for in the design, and interaction between the slab and beam was ensured by shear connectors. In most of the prestressed concrete decks the beams were of such a size and weight that they could be produced in a factory and then transported to and erected on the site. In all cases of prestressed beam construction, the deck, after erection of the beams and the casting of the *in situ* concrete, was transversely stressed.

At Cuerdale Road, where there is a large angle of skew (44 deg.), the bridge is a continuous steel girder over four spans, whilst at Longridge Road provision for large water mains serving Preston required deep girders and, as the motorway is on a curve, a single-span with steel girders was built. The bridge carrying the railway over the motorway at Ribbleton is a through girder type of single span.

The footbridges are three-pin arches, with ribs pre-cast in reinforced concrete, whilst the bridges over the smaller streams are reinforced box culverts.

Design and supervision of construction of the entire Preston by-pass—with the exception of one bridge—has been in the hands of the county surveyor and bridgemaster of Lancashire, Mr. James Drake, M.I.C.E., and his engineering staff. Close co-operation has been maintained with the chief engineer, Mr. J. F. Baker, M.I.C.E., and the north-western divisional road engineer, Mr. V. H. Haynes, A.M.I.C.E., of the Ministry of Transport and Civil Aviation. The bridge mentioned above is the Preston–Longridge railway bridge, which was the responsibility of the chief civil engineer of the London Midland Region of British Railways, Mr. J. Taylor Thompson, M.I.C.E.

The main contractor for the motorway was Tarmac (Civil Engineering), Ltd., the tender price being £2,432,360. The sub-contractor for bridgeworks in this tender was Leonard Fairclough, Ltd., which firm also obtained the contract for the Preston–Longridge bridge. The two large bridges were let separately, the contractors and contract sums being respectively; for Samlesbury bridge, the Cleveland Bridge and Engineering Company, Ltd. (£334,431), and for Higher Walton bridge, Dorman Long (Bridge and Engineering), Ltd. (£193,690). Construction of the main works started in June, 1956, and the total estimated cost, including land acquisition, alteration of services, design and resident staff, has been quoted at £3,147,000.

Assembly Tolerance Problem

By J. W. CROFTS, M.A., A.M.I.Prod.E., F.S.S.*

It frequently happens in engineering that one dimension, which is important for reasons of mating, is determined or constituted by a number of other dimensions, each subject to variation. A common example is the case of the overall dimension of an assembly of several components. Variations in the component dimensions are reflected in variation of the resultant dimension; but, owing to "averaging out," the resultant dimension tends to vary less than might be expected from the variabilities of the components. This article derives an expression for the range of the resultant dimension in terms of the ranges of the components, and gives a table and worked examples. It concludes with some demarcation of the field in which the results may be safely and advantageously utilised.

FIG. 1 shows a case in which dimension R is a resultant of three other dimensions A, B and C. In fact

$$R=A+B-C \quad . \quad . \quad . \quad . \quad . \quad (1)$$

All the dimensions are subject to variation, and the greatest possible value of R will occur if maximum values of A and of B happen to be combined with the minimum value of C, i.e.—

$$R_{max}=A_{max}+B_{max}-C_{min} \quad . \quad . \quad (2)$$

On the other hand, the least possible value of R will occur if minimum values of A and of B happen to be combined with the maximum value of C, in which case

$$R_{min}=A_{min}+B_{min}-C_{max} \quad . \quad . \quad (3)$$

On subtracting equation (3) from equation (2) we obtain a new equation—

$$R_{max}-R_{min}=A_{max}-A_{min}+B_{max}-B_{min}-C_{min}+C_{max} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

i.e.

$$(R_{max}-R_{min})=(A_{max}-A_{min})+(B_{max}-B_{min})+(C_{max}-C_{min}) \quad . \quad . \quad . \quad . \quad . \quad (4a)$$

or

$$\text{Range}_R=\text{Range}_A+\text{Range}_B+\text{Range}_C \quad . \quad . \quad . \quad . \quad . \quad (4b)$$

or again, with more concise notation,

$$r=a+b+c \quad . \quad . \quad . \quad . \quad . \quad (4c)$$

This last equation shows that the range of the resultant is equal to the sum of the ranges of the constituents—regardless whether the constituents contribute positively or negatively to the resultant dimension.

Designer's Dilemma

Let us now consider the case of a number of wheels, collars, &c. threaded upon a shaft

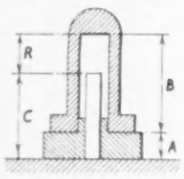


Fig. 1

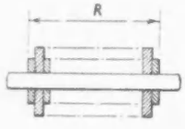


Fig. 2

(Fig. 2). It is desired to limit the overall dimension R to a range of 0·002in. If there are ten components in the group, and the ranges of thickness of all are equal, then the range for each one, according to (4b), must not exceed a tenth of 0·002in, i.e. 0·0002in. In many cases it would be inconvenient and costly to maintain a range as close as 0·0002in, and in some cases it would be impossible.

This illustrates a predicament in which many a designer has found himself. He must either set prohibitively close limits to the dimensions of components, or else accept a range of variation in resultant dimensions which would appear to incur grave risks in the functioning of assemblies. Sometimes a designer is inclined to wonder how it is that his products work as well as they do—and even to credit assembly departments with selective and corrective measures to which, in fact, they seldom resort. There is, indeed, ground for suspecting that the relationship given by equation (4b)—that the range of the resultant is the sum of the ranges of all constituents—is unduly pessimistic, and can sometimes be ignored with impunity.

A glimpse of the reason for this may be gained from the following line of reasoning. Consider the example illustrated in Fig. 2, and suppose that the relevant dimensions of all components lie on either the upper limit or the lower limit—there being no intermediate values—and that we have as many on the one limit as on the other. Let us now estimate the chance of obtaining an assembly of which the overall dimension (R) lies on the top limit (R_{max}) as given by equation (2). The chance of our getting our first component on top limit is $\frac{1}{2}$. The chance of getting the second component on top limit is also $\frac{1}{2}$. The chance of getting both first and second components on top limit is $\frac{1}{2}\times\frac{1}{2}$. Similarly the chance of getting all ten components simultaneously on top limit is $(\frac{1}{2})^{10}$, i.e. 1/1024. Therefore, in the circumstances envisaged, on the average fewer than one in a thousand of the assemblies will reach the top limit, and fewer than one in a thousand will reach the bottom limit, as obtained by summing the ranges of all the components.

In connection with the foregoing illustration there are three points which ought to be emphasised :

(i) No doubt has been cast on the validity of equation (4b). The upper and lower extreme limits given by equations (2) and (3) can, and sometimes will, be reached. What has been shown is that the occasions on which these limits are reached are exceptional, in the sense of being outnumbered by occasions on which they are not reached.

(ii) It is plain that, in the example, if we were prepared to discard one assembly in every 500 (strictly 2/1024) we could say that the effective range of the overall dimension R was somewhat less than the sum of the ranges of the ten components. But we have not so far found out how much less.

(iii) In our illustration we assumed a total absence of intermediate values of component dimensions. In practice intermediate values would normally be present—if not indeed predominant—and in any attempt to solve the problem posed in (ii) this fact ought to be taken into account.

Statement of Problem

The problem of (ii)—the solution of which is the main task of this article—can be stated still more clearly with the aid of Fig. 3. This

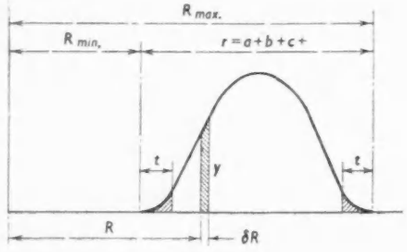


Fig. 3

shows a distribution curve for R, the resultant dimension derived from n constituents having ranges a, b, c, &c. The height y of the curve is such that the area $y\,.\,\delta R$ represents that proportion of all assemblies for which the resultant dimension lies between R and $R+\delta R$. There are no values of R less than R_{min}, nor more than R_{max}. From R_{min} the curve rises from zero, reaches a maximum at some central value round which a relatively large proportion of the assemblies is concentrated, and descends to zero again at R_{max}. If we erect ordinates at $(R_{min}+t)$ and $(R_{max}-t)$, we obtain a reduced "effective" range of $(r-2t)$, which excludes those assemblies represented by the shaded tail areas at the extremities of the curve. Let the ratio

$$\frac{\text{Excluded assemblies}}{\text{Total assemblies}}$$

$$\text{i.e.} \quad \frac{\text{Combined tail areas}}{\text{Whole area under curve}}=p.$$

Our task is to find the relationship between t and p, all the n values of a, b, c, &c., being known. But before we tackle this we must deal with the point raised in (iii) regarding the distribution of component dimensions.

Distribution of Component Dimensions

The relevant dimension of any one component (A, for example), as produced, may well be distributed in some such manner as shown in Fig. 4. The components reaching the assembly department, however, will not

Fig. 4

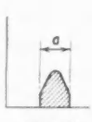


Fig. 5

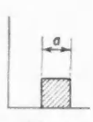


Fig. 6

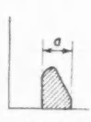


Fig. 7

include the whole of the components produced, because of the activities of the inspection department in eliminating those which lie outside the specified limits. If the limits are wide in relation to the production variations, this discrepancy will not arise, and the whole quantity will reach assembly; but our present concern is with cases in which limits are inconveniently close—i.e. in which it is impossible to avoid producing oversize components except by producing undersize ones, and vice versa. In these circumstances, the distribution curve for dimension A, as received for assembly, will have vertical sides and a humped top, as in Fig. 5. The humpiness of the top, in relation to the height of the vertical sides, will, of course, vary from instance to instance, but we shall evade this complication by taking in all cases a rect-

* English Numbering Machines, Ltd., Enfield.

angular distribution as shown in Fig. 6. This implies equal frequency of occurrence of all values of A between A_{max} and A_{min}.

In replacing the hump by a flat top we are erring on the side of pessimism—that is to say, assuming a greater concentration close to the two extreme values than is likely to occur in practice. On the other hand, in assuming a symmetrical distribution (in contrast to a skewed one such as Fig. 7) we may be erring on the side of optimism. In the hope that the blend of pessimism and optimism represented by the rectangular distribution may facilitate a tolerable approximation to realism, we will now take up the particular case of an assembly of two components.

Resultant of Two Components

We wish to construct a diagram for the distribution of R, when $R=A+B$, and A and B are distributed evenly over the ranges a and b respectively. Assume that we have a batch containing N components of type A and a batch of N components of type B. These will make N assemblies. Let us take first those components of type B, the dimension of which lies between B_{min} and $B_{min}+\delta B$, where δB is an increment small compared with b. In this range (of extent δB) there will be $N.\delta B/b$ components, because the total quantity N is evenly spread over the range b. We now have $N.\delta B/b$ components of type B, the dimension of which lies between B_{min} and $B_{min}+\delta B$ and may be averaged as $B_{min}+\delta B/2$. Let us now combine (i.e. assemble) these with a representative selection of components of type A. By representative selection we mean uniformly covering the

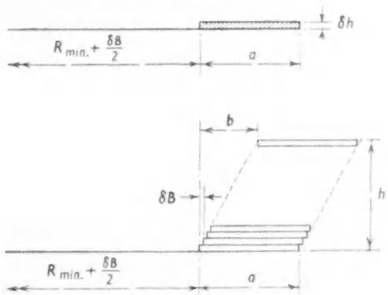


Fig. 8 (top) and Fig. 9

whole range a of dimension A. We now have a group of assemblies, $N.\delta B/b$ in number, for which R (i.e. $A+B$) begins at $B_{min}+\delta B/2+A_{min}$, i.e. $R_{min}+\delta B/2$, and extends a further distance a. This group of assemblies constitutes an elementary strip, as shown in Fig. 8, on our distribution diagram. The area of the strip $a\delta h$ represents the number of assemblies in the group, so

$$a\delta h=N.\delta B/b$$

Therefore,

$$\delta h=N.\delta B/ab.$$

Having now used up all type B components for which B lies between B_{min} and $B_{min}+\delta B$, we may proceed in like manner with those for which B lies between $(B_{min}+\delta B)$ and $(B_{min}+2\delta B)$. This will provide a further elementary strip, staggered by the distance δB in relation to the first one. We may continue thus (Fig. 9) until we have covered the entire range of B, by which time we shall have laid down strips to the number of $b/\delta B$, reaching a total height h, where

$$h=\frac{N.\delta B}{ab}\cdot\frac{b}{\delta B}=\frac{N}{a}.$$

To obtain our distribution diagram for R in final form (Fig. 10) we must take the limit when δB becomes 0, and we must invert the overhanging right-hand portion of Fig. 9. We obtain a trapezium of base $a+b$, which rises to a height of N/a in a distance b. The slope of the sides is, therefore, N/ab, and the height of the shaded triangular portion of width t_2 is Nt_2/ab, and its area is $\frac{1}{2}\frac{Nt_2^2}{ab}$. The combined area of two such tail portions is $\frac{Nt_2^2}{ab}$. Hence p, the proportion of assemblies lying outside the reduced range $a+b-2t_2$, is equal to

$$\frac{t_2^2}{ab};\ \text{or}\ t_2=\sqrt{pab} \quad . \quad . \quad . \quad (5)$$

Let us use the letter s to denote the reduced range $r-2t_2$. Then

$$s=a+b-2\sqrt{pab} \quad . \quad . \quad . \quad (6)$$

This may be converted into an expression for evaluating an unknown permissible range b of one component when the range a of the other component and the maximum permissible range s of the resultant are both known :

$$b=s-a+2ap-2\sqrt{ap(s-a-ap)} \quad . \quad (7)$$

By way of illustration consider a case in which (in units of 0·001in) $s=6$ and $a=5$. If we take $p=0{\cdot}01$ (i.e. 1 per cent of resultants will be unacceptable) we have

$$b=6-5+0{\cdot}1-2\sqrt{0{\cdot}05(6-5-0{\cdot}05)}=1{\cdot}558.$$

According to the orthodox argument b would have been 1. In this instance, therefore, we may increase the range by 55 per cent without causing more than 1 per cent of the resultants to be outside the limits. This may be regarded as a foretaste of the far greater benefits which arise when larger numbers of components are involved.

Modification for Dealing with Greater Numbers of Constituents

In order to facilitate the treatment of cases involving more than two constituents it is advantageous to convert the model which we have employed (Fig. 9) from a two-dimensional one to a three-dimensional one. Imagine that each elementary strip shown in Fig. 9 is a plan of an elementary slab, the rectangular face of which (Fig. 11) is a distribution diagram for the dimension A. The height of this rectangle, i.e. the number of components involved divided by the range over which A extends, is N/a ; but for present purposes we shall draw this on a diminished scale and make the height of the rectangle N/ab. We must now ascertain the effect of this procedure on the thickness δh of the slab.

By an argument analogous to that used in connection with Fig. 8, the elementary volume $\frac{N}{ab}.a.\delta h$ is to represent that number of assemblies for which B lies between B_{min} and $B_{min}+\delta B$, which is $N\delta B/b$. Hence, $\frac{N}{ab}.a.\delta h=\frac{\delta B}{b}.N.$

and consequently $\delta h=\delta B$,

and therefore the dimension h, the thickness of the whole " pack " of slabs, is b.

The " distribution solid," as it may be called, which results when the elementary slabs are reduced to infinitesimal thickness, and correspondingly increased in number, is shown in Fig. 12. The volume of this solid has the same meaning as the area of the distribution diagram in Fig. 10, and it is easy to check that the shaded area $MLKJ$, situated at a distance x from the point of origin, corresponds with the ordinate at a distance x on the diagram of the distribution of the resultant R.

There is another feature of this distribution solid, the importance of which will quickly appear. Since $ML=YL$ and $JK=OK$ (because $h=b$) the shaded cross-section $MLKJ$ is equal to the area $YLKO$ on the face of the solid. Having thus found on the face of our distribution diagram for one component (drawn to an appropriate scale) a measure of the ordinate of the distribution diagram of the resultant, we are spared the necessity of further attempts to draw solids in perspective.

Taking advantage of this discovery, we may now handle the case of two components in the following manner (Fig. 13). Draw the distribution diagram for one component (B) on a scale reduced by division by a. This is $YHGO$, the height of which is $1/ab$. (We have here dropped the quantity N. The consequence will be that henceforward we shall obtain proportions of the whole, instead of actual numbers of assemblies.) Next imagine a vertical band of width b to traverse $YHGO$ from left to right. The leading edge of this band, LK, is shown to have reached a point distant x from O. The doubly shaded area $YLKO$ represents the height y of the ordinate at x of the distribution diagram of the resultant R of A and B. This is shown in Fig. 14, which resembles Fig. 10 except in regard to the omission of N.

$$y_2=OK.LK=x.\frac{1}{ab}=\frac{x}{ab} \quad . \quad . \quad (8)$$

Resultant of Three Dimensions

We can obtain the distribution of the resultant of three components by treating it as the resultant of two components—one of the two being in effect a combination or sub-assembly of the other two components. Fig. 15 illustrates the procedure. $ODEG$

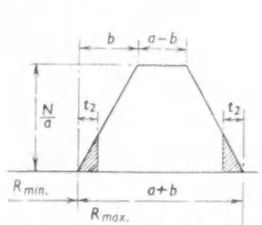


Fig. 10

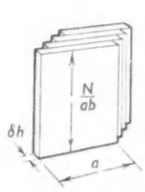


Fig. 11

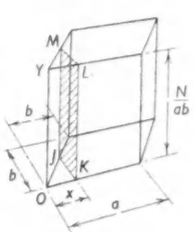


Fig. 12

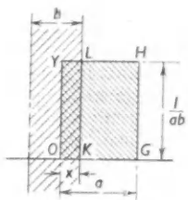


Fig. 13

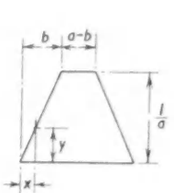


Fig. 14

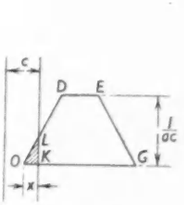


Fig. 15

represents the distribution of the assembly $A+B$, suitably reduced in vertical scale by dividing by the range c of the third dimension C. The vertical band of width c is shown advancing towards the right, its leading edge having travelled a distance x and the triangular area LKO having been overlapped. This area gives us the value of y for the distribution of R. As long as the overlapped area is triangular, as shown (i.e. as long as L lies between O and D, and the rear edge of the strip has not yet reached O), we have

$$y_3 = \Delta OLK = \tfrac{1}{2}(LK)(OK) = \frac{1}{2}\left(\frac{x}{b}\cdot\frac{1}{ac}\right)(x) = \frac{1}{2}\frac{x^2}{abc} \quad \ldots\ldots (9)$$

It is clear from expression (9) that the distribution diagram for the resultant of three components rises in a parabolic manner. Discussion of other features of the shape of the diagram involves reference to differences between one dimension and another, and requires some assumption as to relative magnitudes. We are free, of course, to assign whichever symbol we would to any particular component. We shall adopt the convention of taking components in descending order of range of dimension; that is to say, $a>b>c$.

The parabolic rise OP (Fig. 16) ceases when $x=c$, by which time the rear edge of the moving band has reached O. Thereafter the shaded area takes the form of a trapezium (Fig. 17) which increases in height but not in width as x increases. This corresponds with the straight portion PQ in Fig. 16. At Q, where $x=b$, the leading edge of the band reaches the shoulder D (Fig. 15), and growth continues at an ever-diminishing rate corresponding with the inverted parabolic portion QS. If c is less than $(a-b)$—see Fig. 14—there will be a flat portion ST (Fig. 16), but otherwise this feature will be missing. The descent at the right-hand side is a mirror image of the ascent which has been described. It is to be noted that the distribution of the resultant of three components has a distinct resemblance to the Gaussian form.

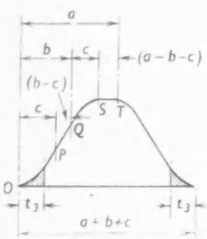


Fig. 16

Fig. 17

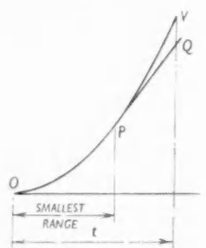


Fig. 18

We have yet to evaluate t. Taking t to be less than c, the area of each shaded portion (Fig. 16) is $\int_0^{t_3} y\,.\,dx$; while, from (9),

$$y_3 = \frac{1}{2}\frac{x^2}{abc}. \quad \text{Hence } p = 2\int_0^{t_3} y_3\,.\,dx = \frac{2}{2abc}\left[\frac{x^3}{3}\right]_0^{t_3}$$

$$= \frac{t_3^3}{3abc} \text{ and } t_3 = \sqrt[3]{3pabc}.$$

If we take $2t=u$, so that $s=r-u$, then $u_3 = 2\sqrt[3]{3pabc}$.

Resultant of Four Constituents

As before, we take y for the previous case (i.e. y_3), we divide it by the range of the new dimension to be taken into account (i.e. d), and we integrate with respect to x. Hence, from (9),

$$y_4 = \frac{1}{d}\int y_3\,.\,dx = \frac{1}{2abcd}\cdot\int x^2\,.\,dx = \frac{x^3}{2\,.\,3abcd}.$$

Moreover,

$$p = 2\int_0^{t_4} y_4\,.\,dx = \frac{2}{2\,.\,3abcd}\int_0^{t_4} x^3\,.\,dx = \frac{2}{2\,.\,3abcd}\left(\frac{t_4^4}{4}\right)$$

$$\text{and } t_4 = \sqrt[4]{\frac{4!\,pabcd}{2}}.$$

The General Case

The procedure which has been described may be repeated indefinitely, and in every case the expression for t will take the form

$$t_n = \sqrt[n]{\frac{n!\,p(a\,.\,b\,.\,c\,.\,d\,.\,\ldots)}{2}}$$

or

$$\left(\frac{pn!}{2}\right)^{1/n}\,.\,M,$$

where M is the geometric mean range of the n dimensions.

It is to be remembered, however, that the equations used in deriving the above expression hold good only if t does not exceed the smallest range a, b or c, &c. This proviso will not always hold good, and the consequences of the discrepancy between assumption and fact must be examined. Let OP in Fig. 18 be the distribution curve for the resultant R up to the limit of the smallest dimensional range (a, b, c, or whichever one it is). Up to this point our formulæ are strictly correct (provided, of course, that our basic assumption of rectangular distributions is valid). We have, however, made no allowance for the fact that beyond P the true distribution curve will begin to rise less rapidly than it would have risen if the range of one dimension had not been passed. In our reckoning of the tail area corresponding with t we ought to have taken the area $OPQU$; but for the sake of simplicity we have actually evaluated the area $OPVU$. We have therefore over-estimated the tail area corresponding with a given value of t, and have under-estimated t for a given value of p. Our error is on the side of safety. At the cost, however, of some complication it can be eliminated.

This will require some further examination of the cases already considered. In Fig. 13 we obtained y_2—the ordinate of the distribution of the resultant of two components—by traversing a band of width b across the rectangle of width a and height $1/ab$. This latter rectangle may be regarded as the difference between two rectangles of equal height, both extended towards infinity in the rightward direction (Fig. 19), but staggered in relation to one another to an extent a at their leftward extremities. Similarly, we may regard the traversing band of width a as the difference between two areas extending towards infinity in the leftward direction and staggered to an extent b at their rightward extremities. When the leading edge LK has reached a distance x past 0 (Fig. 20), we have

y_2 = (Net area overlapped by leading edge) − (Net area overlapped by trailing edge)

$$= \{f_2(x) - f_2(x-a)\} - \{f_2(x-b) - f_2[(x-b)-a]\}$$
$$= f_2(x) - f_2(x-a) - f_2(x-b) + f_2[x-(a+b)].$$

In the above expressions f_2 stands for the factor $1/ab$, and the terms $(x-a)$, $(x-b)$ and $x-(a+b)$ come into operation as and when x exceeds a, b and $(a+b)$ respectively.

We may also write the following corresponding expression for the area of the tail of this distribution, up to the point at which $x=t$:

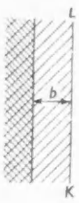
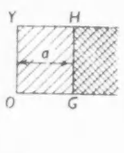


Fig. 19



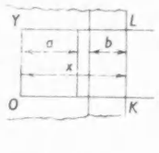


Fig. 20

$$\tfrac{1}{2}p_2 = F_2(t) - F_2(t-a) - F_2(t-b) + F_2[t-(a+b)]$$

in which

$$F_2(t-a) = \frac{1}{ab}\int_a^t (x-a)dx = \frac{1}{2ab}(t-a)^2,$$

and the other terms have corresponding meanings.

Turning now to the case of three components, we obtain y_3 by traversing y_2/c with a band of width c—or, rather, with a leading edge followed by a trailing edge c in arrear. Thus,

$f_2(x)$ becomes $f_3(x) - f_3(x-c)$,
$f_2(x-a)$ becomes $f_3(x-a) - f_3[x-(c+a)]$,
$f_2(x-b)$ becomes $f_3(x-b) - f_3[x-(b+c)]$, and
$f_2[x-(a+b)]$ becomes $f_3[x-(a+b)] - f_3[x-(a+b+c)]$.

Hence,

$$y_3 = f_3(x) - f_3(x-a) - f_3(x-b) - f_3(x-c) + f_3[x-(a+b)] + f_3[x-(b+c)] + f_3[x-(c+a)] - f_3[x-(a+b+c)]$$

in which

$$f_3(x) = \frac{x^3}{2abc}$$

(as in (9) above), and the other terms, which have corresponding meanings, come into operation as and when x exceeds the quantity or group of quantities subtracted from it.

Hence, also,

$$\tfrac{1}{2}p_3 = F_3(t) - F_3(t-a) - F_3(t-b) - F_3(t-c) + F_3[t-(a+b)] + F_3[t-(b+c)] + F_3[t-(c+a)] - F_3[t-(a+b+c)]$$

in which

$$F_3(t) = \frac{t^3}{3!\,abc}.$$

Our modified expression for the general case of n components must now be written:

$$\tfrac{1}{2}n!\,p(a\,.\,b\,.\,c\,.\,d\ldots\text{ \&c.}) = t^n$$
$$-(t-a)^n - (t-b)^n - (t-c)^n - (t-d)^n - \ldots \text{ \&c.}$$
$$+\{[t-(a+b)]^n + [t-(a+c)]^n + [t-(a+d)]^n \text{ \&c.}$$
$$+[t-(b+c)]^n + [t-(b+d)]^n + [t-(b+e)]^n \text{ \&c.}$$
$$+[t-(c+d)]^n + [t-(c+e)]^n \text{ \&c.}\}$$
$$-\{[t-(a+b+c)]^n + [t-(a+b+d)]^n + [t-(a+b+e)]^n \text{ \&c.}\}$$
$$+\{[t-(a+b+c+d)]^n + \text{\&c., \&c.}\}$$
$$-\{[t-(a+b+c+d+e)]^n + \text{\&c., \&c.}\} \text{ \&c.} \ldots$$
$$\ldots\ldots (11)$$

in which, as always, each item in brackets has effect only when positive.

The Case of Equal Ranges

When all the ranges a, b, c, d, &c., are equal, it is natural to treat the common range

as the unit of measurement in terms of which to express t. Equation (11) then becomes

$$n\,!\,p/2 = t^n - n(t-1)^n + C_2^n(t-2)^n - C_3^n(t-3)^n + C_4^n(t-4)^n \text{ \&c.} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

where C_v^n is the number of possible combinations of n things v at a time and, as usual, the successive terms come into operation as t exceeds 1, 2, 3, &c., as the case may be.

As

$$C_v^n = \frac{n\,!}{v\,!\,(n-v)\,!},$$

equation (12) may be rewritten thus :

$$\frac{p}{2} = \frac{t^n}{n!} - \frac{(t-1)^n}{(n-1)!} + \frac{(t-2)^n}{2(n-2)!} - \frac{(t-3)^n}{3!(n-3)!} + \frac{(t-4)^n}{4!\,(n-4)!} \text{ \&c.} \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

This expression may readily be tested by taking $t=n/2$, which corresponds with the mid-point of the distribution so that $p/2$ should be $\frac{1}{2}$. Take, for example, the case when $n=4$. We have

$$\frac{2^4}{4!} - \frac{(2-1)^4}{3!} + 0 = \frac{2}{3} - \frac{1}{6} = \frac{1}{2},$$

which is correct. Or, again, taking $n=7$, we have

$$\frac{\binom{7}{2}^7}{5040} - \frac{\binom{5}{2}^7}{720} + \frac{\binom{3}{2}^7}{240} - \frac{\binom{1}{2}^7}{144}$$

$$\frac{1}{2^7}\left\{\frac{117649}{720} - \frac{78125}{720} + \frac{6561}{720} - \frac{5}{720}\right\}$$

$$\frac{1}{2^7}\left\{\frac{46080}{720}\right\} = \frac{64}{2^7} = \frac{1}{2},$$

which is also correct.

Number (n) of components	Range (s) of resultant / Range of individual component		
	$p=3$ per cent	$p=1$ per cent	$p=0{\cdot}3$ per cent
2*	1·65	1·80	1·89
3	2·10	2·38	2·58
4	2·45	2·82	3·13
5	2·75	3·20	3·58
6	3·03	3·52	3·97
7	3·27	3·83	4·33
8	3·50	4·11	4·66
9	3·72	4·36	4·96
10	3·93	4·61	5·25
11	4·11	4·85	5·52
12	4·30	5·07	5·79
13	4·49	5·28	6·03
14	4·66	5·48	6·27
15	4·83	5·68	6·50
16	4·99	5·88	6·73
17	5·15	6·07	6·95
18	5·30	6·25	7·15
19	5·45	6·43	7·35
20	5·60	6·59	7·55
$n>20$	$1{\cdot}25\sqrt{n}$	$1{\cdot}49\sqrt{n}$	$1{\cdot}71\sqrt{n}$

* Or use $s=a+b-2\sqrt{pab}$, i.e. $b=s-a+2ap-2\sqrt{ap(s-a+ap)}$.

Another test is to make $t=n$, which corresponds with the extremity R_{max} of the distribution, so that $p/2$ should be 1. If $n=3$, this gives

$$\frac{3^3}{6} - \frac{2^3}{2} + \frac{1^3}{2} = \frac{9}{2} - 4 + \frac{1}{2} = 1,$$

which is correct.

Accepting, then, the correctness of equation (13), we may proceed to evaluate t, and hence, s, for various values of p and of n. In the table above the results (s values) are given for $p=3$ per cent, 1 per cent and 0·3 per cent, and all values of n from 2 to 20 inclusive.

The same results are shown in graphical form in Fig. 21, while Fig. 22 shows $2t/n$, which represents the proportionate reduction in range of the resultant, as compared with the simple rule of taking the range of the resultant as the sum of the ranges of the components.

The Standard Deviation Method

The traditional method of approach to our problem, on lines based on the theory of statistics (e.g. "An Investigation into Industrial Design and Drawing Practices in New South Wales, Australia," *Journal of Institution of Production Engineers*, Vol. 33, No. 4, Appendix 3, page 231), has been to argue that :

(1) The distribution of the sum of a large number of individual non-Gaussian distributions is approximately Gaussian, and hence, for a sufficient number of components,

(2) A table of Gaussian tail areas can be used to fix the range in relation to the standard deviation of the resultant, while :

(3) The standard deviation of the resultant can be taken as the square root of the sum of the squares of the standard deviations of the individual components.

The standard deviation of a rectangular distribution of range r is $r/\sqrt{12}$; and the standard deviation of the sum of n such distributions is $\sqrt{n}$ times as great, namely, $r\sqrt{n/12}$. Moreover, the ratio of deviate to standard deviation, to exclude (combined) tail areas of 3 per cent, 1 per cent and 0·3 per cent has the values 2·1701, 2·5758 and 2·9677 respectively. Hence, the ranges of the resultant (corresponding with s above) expressed in terms of the range of one component are, respectively, $2{\cdot}1701\sqrt{n/3}$, $2{\cdot}57588\sqrt{n/3}$ and $2{\cdot}9677\sqrt{n/3}$, since the range is twice the deviate. These expressions can be simplified as $1{\cdot}25\sqrt{n}$, $1{\cdot}49\sqrt{n}$ and $1{\cdot}71\sqrt{n}$, approximately.

These ranges are represented on Fig. 21 by the broken lines. It will be seen that when n is small the "traditional" or standard deviation method gives smaller savings—indeed, if $n=2$ it gives no saving at all—than the method developed in this article ; but that if n is large, say, 20 or more, the two methods closely approximate to one another. This being so, when n exceeds 20 one should adopt the standard deviation method because of its relative simplicity.

Example A.—Sets of twenty-five collars, of which the thickness of each has a range of 0·002in, are threaded upon spindles. What is the range of the overall length of the sets, if we are prepared to disregard up to 1 per cent of the assemblies ?

The range in question

$$= 0{\cdot}002 \times 1{\cdot}49\sqrt{25}\text{in}$$
$$= 0{\cdot}0149\text{in}.$$

Example B.—The range of the overall dimension of an assembly of thirty-six components must not exceed 0·030in, but up to 3 per cent of the assemblies may be disregarded. What is the maximum range that can be permitted for each of the components ?

Let x be the range of the dimension of each component.

Then

$$x \times 1{\cdot}25\sqrt{36} = 0{\cdot}030\text{in}$$

Therefore

$$x = \frac{0{\cdot}030}{1{\cdot}25 \times 6} = 0{\cdot}004\text{in}.$$

When twenty or fewer components are involved, such problems can conveniently be solved by reference to the table, as will now be shown.

Example C.—As Example A above, but there are now only five collars per set.

From the table, when

$p=1$ per cent and $n=5$, $s=3{\cdot}20$.

Therefore, range in question

$$= 0{\cdot}002 \times 3{\cdot}20\text{in} = 0{\cdot}0064\text{in}.$$

Example D.—As Example B, but there are now only seven components.

$$x \times 3{\cdot}27 = 0{\cdot}030\text{in}$$

Therefore

$$x = 0{\cdot}0092\text{in}.$$

Unequal Ranges.—When the ranges of the components are not all equal, it is necessary to take the root mean square value instead of the common range. The following examples illustrate the procedure.

Example E.—Of the twenty-five collars of Example A, fifteen now have a range of 0·003in and ten have a range of 0·002in. What is the new range of the overall dimension, 1 per cent being disregarded ?

Take one-thousandth of an inch as the unit of range. The sum of the squares is

$$15 \times 3^2 + 10 \times 2^2 = 15 \times 9 + 10 \times 4$$
$$= 135 + 40 = 175$$

The mean of the squares is $175/25 = 7$.

The square root of the mean of the squares is $\sqrt{7} = 2{\cdot}646$.

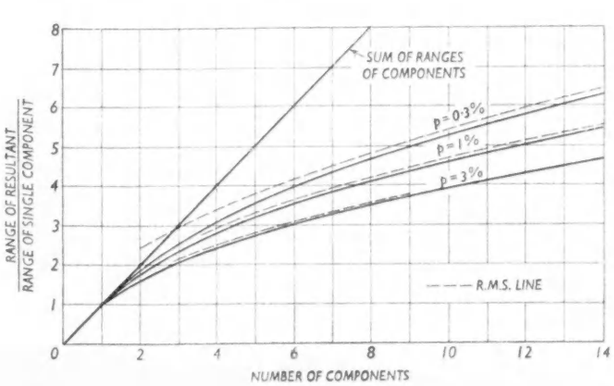


Fig. 21

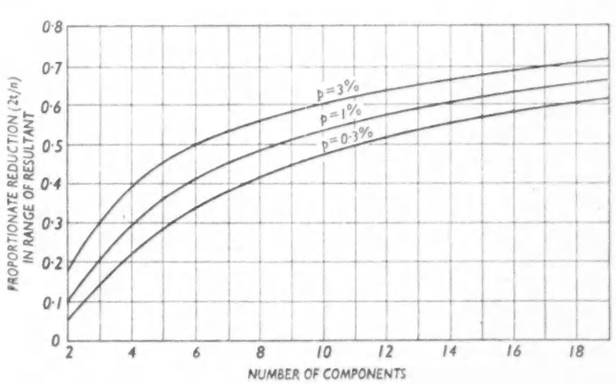


Fig. 22

The root mean square range of the components is therefore 0·00265in.

Hence the range of the overall dimension is $0{\cdot}00265 \times 1{\cdot}49\sqrt{25}$in, i.e. 0·0197in.

Example F.—All conditions are as in Example B, except that twenty of the components have a range of 0·005in. What is the maximum permissible range of the remaining sixteen components ?

In Example B the permissible range for each component was 0·004in, i.e. 4 thousandths. The sum of the squares was therefore 36×4^2, i.e. 576. The sum of the squares for the twenty components of known range is 20×5^2, i.e. 500. Therefore, the sum of squares for the sixteen components of unknown range is 576—500=76. Hence, the mean of the squares is 76/16=4·75, and the corresponding root mean square is 2·18. Therefore, the permissible range for the sixteen components is 0·002(18)in.

Example G.—The ranges of the five components of an assembly are 0·001in, 0·0015in, 0·002in, 0·002in and 0·003in. What is the range of the overall dimension if we may disregard up to 1 per cent ?

The sum of the squares (in the usual unit) is

$$1^2+1{\cdot}5^2+2^2+2^2+3^2 = 1+2{\cdot}25+4+4+9=20{\cdot}25.$$

The mean square is 20·25/5=4·05 and the square root of this is 2·01. Henceforward we treat the problem as if it involved five components of equal range 2·01 and make use of the table, as in Example C. The range in question is $0{\cdot}00201 \times 3{\cdot}20 = 0{\cdot}0064$in.

In the last example we have tacitly assumed the legitimacy of working with the R.M.S. (root mean square) range, while yet resorting to the table for the range (s) of the resultant of a number of components of equal ranges. Strict mathematical rigour would have driven us to formula (11) from which the table was derived ; but this is inconvenient for general use, and the compromise here adopted is remarkably accurate and errs on the side of safety. The approximation may in fact be tested in the following way.

Consider an assembly of five components. Let four of the components have a range of 1 and the fifth a range of 0—thereby introducing inequality of an extreme degree. The sum of squares is $1^2+1^2+1^2+1^2+0^2=4$, and the mean square is 4/5 ; so the root mean square is $\sqrt{\frac{4}{5}}=0{\cdot}8944$. Hence, from the table, taking $n=5$, the range (s) of the resultant is 0·8944 multiplied by 2·75, 3·20 or 3·58, according as p is 3, 1 or 0·3 per cent respectively. These s values are 2·46, 2·85 and 3·20. So much for our values derived from the R.M.S. compromise. Now in the case considered we took four variable components and one invariable one. The range of the resultant is therefore strictly that of the four variable ones, and can be obtained from the line of the table for $n=4$, which gives 2·45, 2·82 and 3·13. These, then, are the exact values with which our previous estimates of 2·46, 2·85 and 3·20 are to be compared. It is to be noted that the estimates are close, but err on the side of safety (i.e. they slightly exaggerate the range of the resultant).

Discussion of the Applicability of the Results of this Article

Consider the following case. A certain assembly consisted of a number of flat components which had been pressed out of strip material of (the same) specified width and thickness. All the material was of the maximum thickness permitted, and consequently all the assemblies had an overall dimension $R_{max}=A_{max}+B_{max}+C_{max}$, &c.

Clearly the theory developed in this article did not apply.

Here is another case. An assembly consisted of a number of washers which had been made by parting off from bar in an automatic lathe. At the beginning of the run the washers were on bottom limit, but as the tool wore the thickness of the components increased, and by the end of the run they were on top limit. When the washers reached the assembly department all the thin ones were at the bottom of the container and all the thick ones lay on the top. Consequently, the first assemblies produced were all oversize and the last ones were undersize. Again, the theory of this article did not apply.

It is clearly necessary to exercise considerable discrimination and the following points should be observed.

(1) If (as in the second of the above cases) there is a gradual trend of the dimension from one limit to the other, the components should be deliberately mixed up in order to randomise them. If several batches, produced on different occasions, can be mixed together, so much the better.

(2) Provided that the component dimensions really do vary over the ranges assumed, and that they are well randomised, then the theory will give a correct (or, rather, a safe) estimate of the range of the assembly dimension. The difficulty is that (as the first of the above cases illustrates) the tolerance limits are one thing and the range of variation is another—sometimes very different—thing. When, however, the tolerance limits are uncomfortably close, the range of variation does tend to correspond with the tolerance range, and it is precisely in these circumstances that the easement afforded by the theory of this article is particularly welcome.

(3) In practice, evidence of correspondence of range of actual variation with tolerance range will take the form of appreciable and approximately equal numbers of oversize and undersize rejects occurring on inspection. If, say, 5 per cent of the quantity were oversize and 5 per cent undersize, one would feel confident that the distribution (*a*) did extend over the whole range of tolerance, and (*b*) was approximately symmetrical. If, on the other hand, there were, say, 15 per cent oversize and 2 per cent undersize (or vice versa) one would suspect too great a degree of asymmetry for safe application of the present theory.

(4) If an assembly contains several components of the same kind one must be more cautious in applying the theory of this article than if all the components are different.

Electronic Computer Exhibition

No. III—(*Concluded from page* 877, *December* 5)

About 40,000 *people from* 41 *countries, including Czechoslovakia, East Germany and the U.S.S.R., visited the Electronic Computer Exhibition which was held at Olympia, London, from November* 28 *to December* 4. *More than forty firms took part in this exhibition, which emphasised the rapid progress that has been made in Great Britain in developing a great variety of computers and applying them to commerce and industry. Many computers were seen in operation. A symposium of twenty-four papers on the computer as an aid to management was held during the exhibition to enable potential users to benefit from the experience of actual users. The exhibition and symposium were organised jointly by the Electronic Engineering Association and the Office Appliance and Business Equipment Trades Association. Below we conclude our description of some of the exhibits.*

English Electric Company, Ltd.

THE " DEUCE " computer was the basis of the exhibit presented by the English Electric Company, Ltd., Marconi House, Strand, London, W.C.2. It will be recalled that " DEUCE " (Digital Electronic Universal Computing Engine) was developed from the pilot model of the " ACE " computer, which was built at the National Physical Laboratory, Teddington, Middlesex. " DEUCE " was designed to carry out quickly and accurately the voluminous mathematical calculations involved in complex scientific and technical problems. Standard punched card equipment was used for input and output, with thirty-two columns of eighty-column cards, which was found to be adequate for the majority of tasks that were presented to " DEUCE " in its original form. But as programming techniques developed and the scope of the computer became more generally appreciated it was evident that the thirty-two-column punched card input and output was insufficient for the problems propounded for solution by users. Nor was it suited to the growing demands of commercial users of computers.

Accordingly, a new version of " DEUCE " known as " DEUCE " Mk. I, was developed ; it used sixty-four of the available eighty columns of a punched card and virtually doubled the input and output of the machine. It is a general-purpose equipment, still intended mainly for scientific work, but has the facility for using magnetic tape as a storage medium if required.

For the more recent application of the computer to commercial data processing speedy handling and analysis of large masses of data are needed and fast input and output facilities are essential. The " DEUCE " Mk. II computer has been introduced to meet this need. This computer is equipped with a combined input/output machine which is completely buffered and can read and punch the whole eighty columns of the standard punched card ; magnetic tape is normally fitted to provide auxiliary storage.

In certain kinds of data processing, however, a larger high-speed store is useful and the " DEUCE " Mk. IIA has been introduced to give a 50 per cent increase in high-speed storage capacity compared with " DEUCE " Mk. II. With this increase in high-speed storage capacity programmes and data can be handled in larger blocks, recourse to the backing store being less frequent.

" DEUCE " is a serial machine which works in the binary mode and has a pulse repetition frequency of 1 Mc/s. It uses a " word " length of thirty-two digits and a word time of 32 micro-seconds. Typical operation times are multiplication and divi-

sion 2 milliseconds, addition and subtraction 32 microseconds. Another 32 microseconds are needed to allow for the analysis of each instruction by the control circuits. But usually several operations (up to thirty-two) can be done by the same instruction. All arithmetic operations are fixed-point, but many floating-point sub-routines are available. A single-length and a double-length accumulator are included and the latter can be used as two single-length units. There are two kinds of storage and a third (magnetic tape) is available as an optional extra. Mercury delay lines are used for the high-speed store associated with the computing circuits. A magnetic drum provides the larger capacity backing store, with its longer access time, information being transferable in blocks between the two stores. Each instruction specifies the transfer of one or more words from a source to a destination, a total of thirty-two sources and thirty-two destinations being available. Optimum programming is adopted to effect maximum operating speeds, but optimum programming is not necessary for the backing store.

The high-speed store consists of twelve long mercury delay lines, each giving a delay of 1024 microseconds, to accommodate thirty-two words with a random access time of 496 microseconds. Instructions can be obeyed directly from eight of these lines. There are also four short delay lines, each holding one word with immediate access ; three short lines, each to hold two words with an average random access time of 16 microseconds ; and two short lines, each to hold four words, with an average random access time of 48 microseconds ; the high-speed store therefore holds a total of 402 words. In " DEUCE " IIA there are seven extra-long delay lines, whence instructions can be obeyed directly, increasing the total high-speed storage to 626 words. The backing store is a magnetic recording drum driven at 6510 r.p.m. and carrying 256 tracks of thirty-two words each ; there are sixteen reading heads and sixteen writing heads. Several separate operations can be carried out simultaneously—for example, transfer to or from the magnetic drum, transfer to or from the magnetic tape, multiplication, division or logical operations.

Twin transporter units (each consisting of two tape transporter mechanisms mounted in a single console) provide the magnetic tape facilities for " DEUCE." The standard form of computer can accommodate up to four twin transporter units, but this number can be increased by modifying the computer circuits.

A number of programme testing aids are incorporated, including a high-speed store display consisting of two cathode-ray tubes upon which all the thirty-two words of a long delay line can be inspected simultaneously. Other aids are an automatic programme display and a " request stop " facility whereby the computer can be instructed to go ahead with the test programme at full speed until it reaches an instruction of a specified form, whereupon the programme is stopped to allow the contents of the stores to be examined. Operators can be seen checking the contents of the computer in Fig. 11, which shows a " DEUCE " computer being used by Bristol Aero Engines, Ltd., for calculations on engine performance and design.

There are four main facilities provided by the English Electric " DEUCE " service. First there are two computing centres, one in London and one in Stafford, where users can hire time. Secondly, training facilities are available for customer's engineers and programmers. Thirdly, the " DEUCE " Users Association provides after-sales liaison. Fourthly, there are mobile service teams for scheduled maintenance and emergencies. An extensive library of programmes and sub-routines has been built up for a variety of applications and is available to all " DEUCE " users.

Two analogue equipments were also featured by the English Electric Company, Ltd. One is a general-purpose equipment known as " LACE," which was originally developed for use within the company and is now being manufactured commercially. The other equipment is a nuclear reactor simulator.

" LACE " is a self-contained analogue computer with its own power supplies, amplifier units, multipliers, function generators and wave-form generators, capable of handling problems involving up to twelfth order equations. For problems of greater complexity two or more " LACE " equipments can be linked together. " LACE " has been used for studying multi-loop servo systems, airframe vibration, wing flutter, flexible beam behaviour, point-to-point train timing, and neutron flux density and distribution in a cylindrical reactor.

The English Electric nuclear reactor simulator is a simple analogue computer intended as an aid in the training of nuclear reactor operators. It is designed to solve equations which represent some of the conditions in a reactor during operation, and provision is made for these conditions to be controlled or varied as required, to give the operator the " feel " of a reactor system. The simulator is housed in an upright steel-framed cubicle 6ft high by 2ft wide by 2ft deep. The cubicle is sub-divided into three separate sections, the top section containing five computing amplifier units and a servo-multiplier-amplifier unit, all built on withdrawable type chassis. Only four of the computing amplifier units are normally in operation, the fifth being a spare which can be connected in circuit when required.

All connections to the computing amplifier units are made through a plug and socket arrangement which are mated when the chassis unit is inserted in its recess on the main cubicle. Automatic drift correction is not incorporated in the computing amplifier units but provision is made for this adjustment to be carried out manually. A set-zero switch and associated screwdriver adjusted potentiometers are mounted on the front panel of each amplifier unit, and the amplifier outputs can be monitored by a meter. The control system is mounted in the centre section of the cubicle, and control facilities and indicating meters are all mounted on the face panel associated with this section. These facilities include selector switches for setting up various conditions on the following : control rod movement (fine control, coarse stepped control or variable constant velocity control), neutron source, fuel selection, δk step, built-in reactivity, trips for power level and period, mass flow selection, δk scaling, gas inlet temperature. There are also indicating meters showing excess reactivity, control rod position, reactor period, nuclear power and fuel surface temperature.

Computing components are readily accessible at the rear of the amplifier panels. A table-top is fitted immediately below the control panel, at approximately desk top height, for the operator's use. A folding table-top at the same level is fitted to the side of the cubicle to support a recorder when this is required.

The lower section of the cubicle contains the power units which provide h.t. and l.t. supplies to the computing amplifier units and are fed from single-phase 50 c/s a.c. mains.

The reactor equations are simulated by three basic computer elements, the nuclear power computer, heat transfer computer and the excess reactivity computer. These elements are connected in a closed loop circuit which has provision for certain signals to be injected at required points.

Signals representing " built-in reactivity," " fuel temperature " and " control rod position " are fed into the excess reactivity computer which, from this information, produces the δk signal. The position of the control

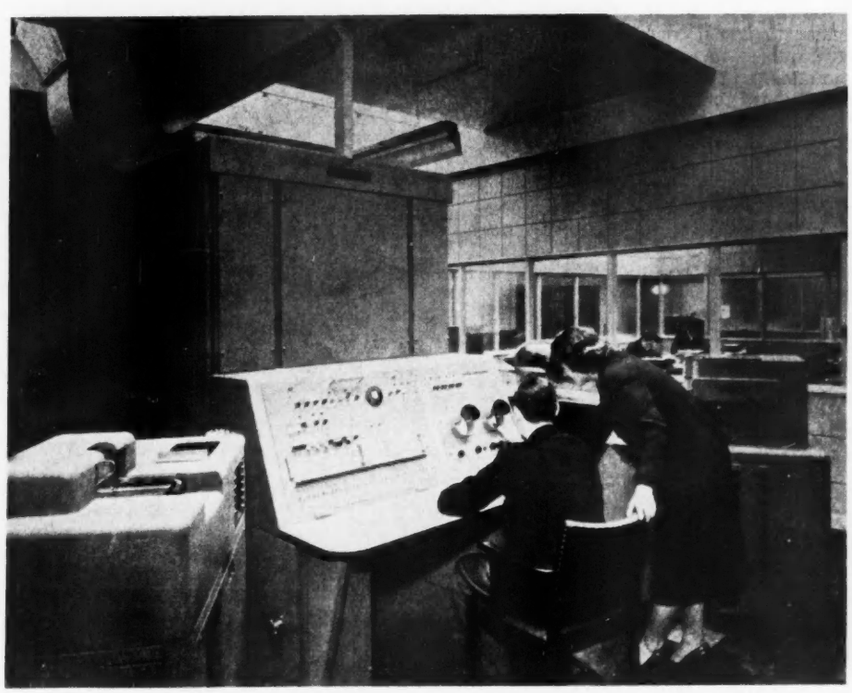


Fig. 11—" DEUCE " electronic digital computer in use for calculations on engine performance and design at Bristol Aero Engines, Ltd.—English Electric

rod may be varied transiently, or by a fine manual control, or may be set to move at a required velocity. The δk signal, together with a neutron source signal, set at the control panel, constitute the input information to the nuclear power computer. This unit comprises a d.c. amplifier which, when fed with this information, simulates the appropriate transfer function, together with the delayed neutron effects. Delayed neutron networks, appropriate to the fuels selected, are set by the "select fuel" potentiometers on the control panel. The loop is closed by feeding the nuclear power signal from the output of the nuclear power computer to the input of the heat transfer computer, together with a signal representing the coolant input temperature. The "mass flow" control may be used to illustrate how the power of a reactor can be controlled by coolant mass flow. Trip circuits are included in the circuit and can be set to simulate shut-down at a preset level or at some defined rate of increase of the power level.

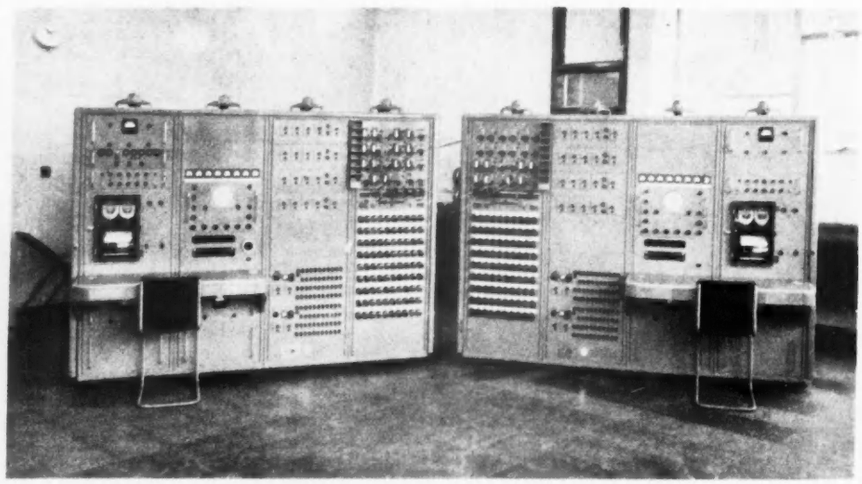


Fig. 13—An eight-bay analogue computer recently built by Saunders-Roe Electronics Division for the De Havilland Aircraft Company, Ltd. This machine has a large programme of work in aircraft stability, ballistics, interception and flutter problems involving six degrees of freedom—Saunders Roe

The Fairey Aviation Company, Ltd.

A multi-purpose analogue computer (Fig. 12) was shown by the Fairey Aviation Company, Ltd., 24, Bruton Street, London, W.1. It is designed for carrying out calculations (usually involving the solution of dynamic equations of a system or plant) which are too complex for normal manual solution because of the large number of non-linearities involved.

The computer is designed on a unitary basis to fit standard 19in by 6ft racks. A comprehensive range of elements is available enabling a computer of any desired size or complexity to be built up. The machine is so designed that an operator may set up a programme without having an intimate knowledge of the internal electronic circuitry. The design also ensures a minimum loss of computer time in servicing. The basic arrangement comprises a control rack, housing control and distribution equipment for up to ninety-six operational d.c. amplifiers. Facilities for amplifier zero checking in the standby condition and overload indication during problem run, are also included. A digital voltmeter is provided for setting initial conditions, voltages and coefficient potentiometers.

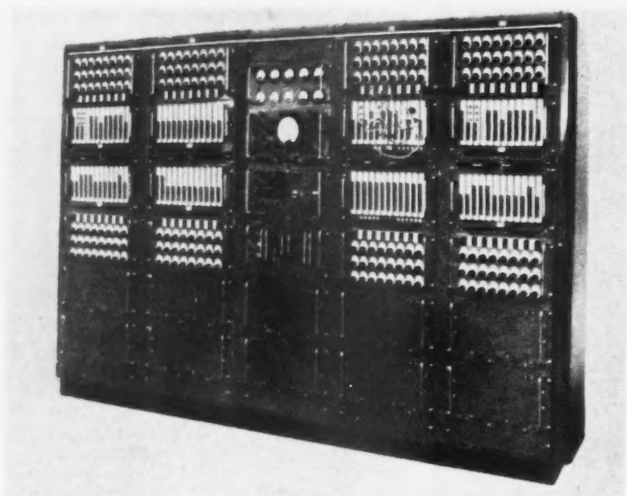
The basis of the computer is the computing panel which houses twelve standard d.c. operational amplifiers. These amplifiers, which are in the form of a thin slab, plug into the back of the panel. The front portion of the panel contains a number of compartments into which function units, containing feedback components, may be plugged. These units are available for a wide range of linear and non-linear mathematical functions; depending on complexity they embrace one or more operational amplifiers.

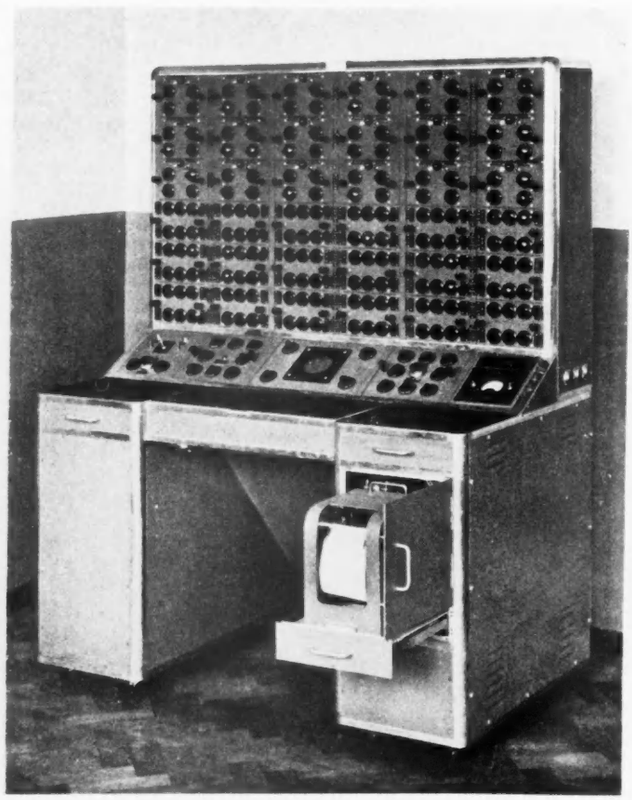
A servo-function unit containing an electromechanical function unit, a number of buffer amplifiers, and a servo amplifier, is also available. A range of interchangeable electromechanical function units are available having various applications, including multiplication, division, angle resolution, &c. Two methods of problem patching are provided, one of which consists of directly interconnecting the function units by plugging in short lengths of cable, the second method being a central patching system where problem boards are interchangeable and removable for programming remote from the computer. Solutions can be displayed or recorded on multichannel cathode-ray oscillographs, quick response direct-writing recorders, or on X-Y plotters according to customers' requirements.

Other Analogue Computers

Two other analogue computers are illustrated here. The first (Fig. 13) is an eight-bay analogue computer recently built by the electronics division of Saunders-Roe, Ltd., for the de Havilland Aircraft Company, Ltd. This computer is being used for a large programme of work in aircraft stability ballistics, interception and flutter problems involving six degrees of freedom.

The second computer is a compact elec-





Figs. 12 and 14—(Left) Electronic analogue computer for general purpose calculations, involving solution of non-linear dynamic equations such as in servo-mechanisms—Fairey. (Right) General purpose analogue computer for solution of differential equations and simulation of physical systems—Short Brothers and Harland

tronic instrument (Fig. 14) intended both for the solution of differential equations and the simulation of analogous physical systems. It was exhibited by Short Brothers and Harland, Ltd., Belfast. A number of instruments of this kind are in use by government and industrial establishments at home and abroad.

THE BRITISH TABULATING MACHINE COMPANY, LTD.

Displays and demonstrations designed to give potential users a balanced picture of electronic data processing were arranged by the British Tabulating Machine Company, Ltd., 70, North Row, London, W.1. The main working exhibits were the "1201 Hec" electronic digital computer, and the "555 Hollerith" electronic plugged programme computer. An unusually interesting application, that of production control, was the subject of a demonstration based on the procedure used in applying computers to production control in the company's own Letchworth factory.

With regard to future developments some advance information was available concerning the "1400" computer, which is now being developed and is expected to go into production within about two years. The concept is that of a balanced data processing system designed so that the composition of its elements can be varied to constitute, at minimum cost, a flexible installation for the effective and economic exploitation of computer techniques. The computer will have variable quantities of high-speed storage and drum storage and different combinations of input and output devices will be available. Provision will be made for the use of magnetic tapes as an alternative for both input and output devices. Because of the possible combinations of the available basic elements this computer should be adaptable in capacity and scope for use by organisations of all sizes.

BRITISH THOMSON-HOUSTON COMPANY, LTD.

A working model of an interesting position-control system, known as "Helisyn," was demonstrated by The British Thomson-Houston Company, Ltd., Rugby. The "Helisyn" is a device, at present under development, for achieving precision linear mechanical positioning in response to a numerical input with particular application to machine tool control and automatic inspection. It consists of a short cylindrical part which is movable along (but is not in contact with) a longer cylindrical part, each part being provided with conductive paths in the form of interlaced helices. One of the elements of the "Helisyn" is excited electrically by appropriate voltages set up in accordance with the input number, which causes an electrostatically induced misalignment signal to appear on the other element. The exhibit consisted of laboratory apparatus arranged to accept decimal input defining a position to one ten-thousandth of an inch, and to show that the combination of digital/analogue converter and "Helisyn" may be used to carry out mechanical positioning to an order of accuracy consistent with that of the input. The model also showed that the "Helisyn" is sensitive to relative rotation of its elements and that this characteristic, though not essential to the functioning of the system, may be used, for example, for setting of the mechanical datum.

E.M.I. ELECTRONICS, LTD.

A number of advanced electronic computers, shown for the first time, were displayed by E.M.I. Electronics, Ltd., Hayes, Middlesex.

The exhibits included the "EMIDEC 1100," a high-speed computer which, with its input and output equipment and magnetic tape units, is designed as a comprehensive and flexible data-processing system for handling tasks varying from the clerical work of a medium-sized business to the complex problems of a large commercial or industrial organisation. By making use of plug-in unit construction each section can be independently built and connected to its neighbours to form a complete machine.

Part of another digital computer, the "EMIDEC 2400," was also exhibited. This equipment will form the basis of a new large, high-speed, data processing system. Its input multiplexing system is designed to effect accurate data processing at unusually high speeds. The speed and capacity of the machine will, it is stated, enable it to handle the clerical work of the largest commercial organisations in this country, and, for example, to cope with the combined input of information provided by 300 typists working continuously. "EMIDEC 2400" is being developed by E.M.I. Electronics, Ltd., in conjunction with the National Research Development Corporation.

Developments in analogue computing were also on show. "EMIAC II," a general-purpose analogue computer, was shown at work on typical problems of calculation and simulation that occur in science and industry. For maximum flexibility in use this computer is designed in modular form, all the standard computing elements being readily interchangeable. Modules can be added to existing installations to enable problems of greater complexity to be tackled. An "EMIAC" computer is already installed and working on problems concerned with nuclear reactors. Another large installation is being supplied to an aircraft firm for use on problems associated with guided missiles.

Ancillary equipment shown for the first time included an 8000-word digital magnetic storage drum with 128 information tracks and additional clock and spare tracks. Special read and write heads are built into the assembly.

A new 200in-per-second digital tape deck, with fast start and stop facilities, and carrying up to twenty-four information channels on 1in tape, was also on show, together with a versatile instrumentation tape deck designed to provide up to twenty-four channels on fourteen spools of 1in tape. Speeds between ½in per second and 120in per second and electrically selected wide speed ratios, are properties of this instrumentation tape deck.

STANDARD TELEPHONES AND CABLES, LTD.

Prominent among the lower-priced computers made in Great Britain is the "Stantec-Zebra," which was shown by Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2. This computer, which was originally designed by mathematicians for use by mathematicians, has proved useful in various kinds of scientific research and in engineering and design work. One application, which was described in a paper presented at the Business Computer Symposium, is that of determining the most economical use of available raw materials in the production of a specific range of end products. Another "Stantec-Zebra" machine is being used to facilitate the making of geographical surveys by analysing data on aerial photographs. Yet another application is to calculations in aircraft design problems.

Audio Frequency Spectrometer

WE have received details of the "Model 2110" audio frequency spectrometer made by Brüel and Kjær, Nærum, Denmark (Agent: B. and K. Laboratories, Ltd., 4, Tilney Street, London, W.1).

This instrument has been developed principally for the rapid and accurate analysis of complex signals such as the ones encountered in noise and vibration measurements. It may, however, also be used as a true R.M.S. reading vacuum tube voltmeter and for harmonic analysis of electrical signals. It contains thirty bandpass filters of very high selectivity (40 dB

Audio-frequency analyser which by means of thirty bandpass filters divides the 35 c/s to 35,000 c/s range into one-third octave sub-ranges. Used with an automatic recorder, the instrument can, it is stated, prepare a complete frequency amplitude diagram in twenty seconds

rejection at two times passband centre frequency) and zero passband attenuation, which serve to divide the frequency band 35 to 35,000 c/s into one-third octave ranges. The inputs to all filters are paralleled, and frequency bands selected by means of a switch in the filter output circuit: the switch can be operated manually or be driven automatically by an external motor. When the motor drive of the graphic level recorder "Model 2304" is used for this purpose the switching operation can be synchronised with the paper drive of the level recorder in such a way that spectrograms (frequency-amplitude diagrams) are recorded automatically on pre-printed, calibrated recording paper. Due to pre-loading of the filters, ringing time is kept to a minimum, and a complete frequency amplitude diagram can be recorded in less than twenty seconds.

A very important feature of the spectrometer is its ability to measure not only the arithmetic average value of the input signal, but also the true R.M.S. value (for signals with crest factors up to 5), as well as the peak value. The desired kind of indication is selected by means of a switch. The instrument can also be switched to operate as a linear amplifier and VTVM in the frequency range 2 to 35,000 c/s. Two different meter damping characteristics are provided so that accurate measurements and easy meter reading are obtained also at the lower frequencies. In addition, the four internationally standardised weighting networks for sound level measurements are included and can be switched in whenever desired. Input and supply voltages for "B. and K." condenser microphones are provided.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

"DIRTY HANDS"

SIR,—In one's more complacent moods one can feel some sympathy with the point of view E. G. Semler expressed in your issue of November 14, although there appears to be a somewhat Hibernian slant to his philosophy. His implication that learning to do a job correctly requires experience of doing it incorrectly is particularly dubious. This may be seen by considering his grumble about car designers who place the least reliable components in the most inaccessible places.

The essential difference between a modern car and an older one, is the greater reliability of the former. The placing of components has not changed, it's just that the older cars were so unreliable that a fair percentage of faulty components could not help but be within easy reach! Instead of a need for elementary ergonomic principles as your correspondent suggests, the aim should be to produce components which do not require attention wherever they are placed! Indeed if this aim could be realised, the components might then be placed in a position so inaccessible that even the most enthusiastic amateur could not get at 'em!

Taking another point, "a man who had never used a spanner," if one could be found, may be particularly valuable in that he is more likely to produce a new and better fixing device than a man who has made considerable use of this blunt instrument and who invariably thinks of nuts and bolts—especially those with a vintage thread form. The whole question of practical training is bedevilled by confused thinking about the value and nature of experience. The sort of experience which makes a man imitate what he has seen before is of little value.

Someone has told the story of the headmaster who would not support the teacher's application for a rise because he felt the teacher had not really had twenty years' experience but merely one year's experience twenty times. The story is not without its pertinence to industry and the situation in which we find ourselves to-day when, one suspects, many advantageous schemes are held in abeyance because some experienced engineers have developed a negative attitude of quickly being able to tell that new schemes will not work. Indeed one feels that given sufficient experience it is possible to predict that nothing at all will work. Your other recent correspondence about turning railways into roads prompts me to suggest that if Stephenson had been junior to some of our more experienced present-day engineers, the situation would never have arisen since we would not have had the railways at all.

However, few will disagree with Mr. Semler about the need for practical training on the actual shop floor and many will warmly support his contention that it is wrong to leave the apprentice to his own devices or to the ministrations of his "mate"—not that these latter are as inarticulate as your correspondent suggests. The most important help to a successful practical training is so to obtain the good will of older men that the apprentice receives the benefits of their experience and not its disadvantages. To gauge this there should be imaginative examinations and one form that this might take is for the apprentice to examine an old patent specification and decide how it could be made into a workable proposition.

The whole matter is better left to individuals than to committees even those of the Institution of Mechanical Engineers mentioned by your correspondent. If Noah had been a committee we should not be here now to debate the matter.

I trust that no one will feel that I am at all disrespectful to those many wise and truly experienced engineers to whom the country and the world owe so much, my whole point being that hardening of the arteries at ninety is less mortifying than losing the imagination at nineteen.

CHARLES SIGSWORTH, M.Eng.

75, Lincoln Road,
Walsall, Staffs,
December 4, 1958.

"OVERTAKING THE CAPITALISTS"

SIR,—Your interesting leader of November 28 gives some of the reasons why Russian output per head may overtake that of capitalist countries. May I suggest, however, that a main cause of the more rapid increase in Russia is because their productive capacity is fully used. Thus, in Mr. R. M. Robbins' letter in the same issue, under the heading of "Mr. Watkinson's Missing Links," the writer, says that "The Victoria Line would cost, with rolling stock, about £55,000,000, but lack of finance stands in the way of this vital improvement for London, for which Parliamentary powers have already been obtained."

In Russia, the construction of such a line would not be held up if the capacity of the engineering contractors was available, because the finance, or paper accounting would be provided. In the capitalist countries the difference is that, although the capacity to build or produce may be available, it does not follow that the finance will be provided. Hence the idle capacity, restricted output and a major handicap in increasing productivity.

Unless the capitalist countries overhaul their obsolete financial system, which is based on paper money being considered something of intrinsic value, they are liable to lose the race with Russia—or worse.

Have we learned nothing from Keynes when he said: "It is a question of manpower and materials, not of finance . . . . ?"

ANTONY VICKERS

Fluidrive Works,
Worton Road,
Isleworth, Middlesex,
December 2, 1958.

Book Reviews

Causes and Prevention of Corrosion in Aircraft. By T. C. E. TRINGHAM. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 25s.

FOR a civil aircraft to be competitive in world markets to-day, the empty weight must be kept to a minimum consistent with safety. That most important factor of lightness depends greatly upon the corrosion resistance of the materials. The author says that, in well-maintained aircraft, so little corrosion occurs that, when it is found, many engineers take little notice of it. When, however, the "odd spot" of surface corrosion shown in Fig. 7 on page 11 represents the dangerous intercrystalline attack seen in section in Fig. 8, it cannot safely be neglected. The author's purpose is to define the many causes of corrosion and to detail the measures which should be taken to prevent its incidence. In this he has been very largely successful, and a study of the book will be most profitable to all concerned in the design and maintenance of aircraft.

The chapter headings are: An Introduction to Corrosion; Sources of Corrosion in the Manufacturing Processes; Storage Procedures; The Aircraft in Service; Causes and Prevention of Corrosion in Engines and their Associated Components; Corrosion in Electrical Equipment; Cleaning Metal Prior to Electroplating; the Electroplating Processes; Anodic Oxidation of Aluminium and Chromating of Magnesium; The Metallizing Processes; The Pre-treatments of Metal Prior to Painting; Paints, Enamels, Varnishes and Resins for Protecting Aircraft Components; Non-destructive Examination; Aircraft Salvage. There are two appendices, one comparing hydrometer degrees, Baumé and Twaddell, with specific gravities; the other comparing the Fahrenheit and Centigrade scales. Of the thirty-five figures, sixteen are examples of different types of corrosion attack. The book is not intended to be a treatise on the mechanics of corrosion, but the author hopes that it will present to the practical engineer a simple outline of the problem with which he is confronted and make a small contribution to the safety of aircraft. This it undoubtedly does. There are, however, a number of matters which could be amended or amplified with advantage in a second edition.

On page 5, the author gives the electromotive or electrochemical series, in which the metals and alloys are listed in order of their single electrode potentials expressed in volts, in solutions of their ions containing 1gm.-mol. per litre. The position in the series enables one to deduce the probable corrodibility of the material. In this list, such materials as the austenitic stainless steels and 12 per cent chromium steel are shown as occupying positions towards the "noble" or non-corrodible end of the series. This is correct only when these materials are in a passive state, i.e. with their surfaces covered with an invisible oxide film. When in an active state, they occupy a position comparatively near to the "base" or corrodible end of the series. Again, a corrodible metal, such as aluminium, which covers itself with a protective film, may be much more resistant in certain conditions

than another, which from its order in the electromotive series should be superior in this respect. The author does not mention these qualifications.

On page 8, the author says that "the surface corrosion of copper is verdigris, this being the basic acetate of copper." This compound is certainly so known, but the patina or green corrosion product on copper exposed to atmospheric attack is not the basic acetate, but usually the basic sulphate ; the carbonate, if present, being a minor constituent. The active reagent is sulphur dioxide, found more freely in industrial atmospheres. The composition may finally reach that of the mineral, brochantite, $CuSO_4 \cdot 3Cu(OH)_2$. In marine conditions, the basic sulphate tends to be replaced by the basic chloride, and the patina tends to reach the composition of atacamite, $CuCl_2 \cdot 3Cu(OH)_2$. When established, the natural patina is highly protective against further attack, but this may require a long time. Artificial patinas can be developed by chemical attack.

On page 12, the author says that intercrystalline corrosion is due to a difference in electrical potential between crystal and boundary, so that, in the presence of an electrolyte, these react with each other as anode and cathode. There are other reasons for this effect, such as the presence of some other constituent at the grain boundaries, as by the precipitation of a particular phase during slow cooling. Thus, some aluminium alloys containing copper and magnesium show the deposition of $CuAl_2$ and Mg_2Si at the grain boundaries, leading to intercrystalline corrosion on exposure to sea water. The author describes the "weld decay" of austenitic stainless steels, as may result from heating the steel in the temperature range, 900–500 deg. Cent., or from slow cooling through this range ; but he does not give the cause. It is due to the precipitation of carbides, chiefly $Cr_{23}C_6$, as a continuous film at the grain boundaries, a region round each carbide particle being thus depleted of chromium and therefore of much lower corrosion-resistance, so that intercrystalline attack will readily occur. This can be prevented by the addition of a stabilising element, such as niobium (in proportion at least ten times the content of carbon), when stable niobium carbide, instead of chromium carbide, is produced, and the alloy is no longer liable to this effect. Titanium can be similarly employed. On page 21, the author says, in reference to welding stainless steels, that the completed weld should be examined for evidence of weld decay, but he does not say how. Susceptibility to this effect can be determined by the Strauss test, involving first heating the alloy in the sensitising zone, and then exposing it to the attack of a 10 per cent sulphuric acid—10 per cent copper sulphate solution for seventy-two hours. If this gives rise to intercrystalline attack, slight bending will lead to a roughening of the surface, while, in extreme cases, the metal will disintegrate completely. Metal thus corroded will also sound "dead" instead of giving the usual ring when struck. Such tests must be applied to a test weld, made at the same time and under the same conditions as the weld in question.

On page 14, the author says that corrosion fatigue can be caused by the pits and notches created by corrosion, and that failure is transgranular. This statement could with advantage be amplified. If one takes a longitudinal section through a pump shaft showing corrosion fatigue, the cavities are seen to be very deep, and to have extremely acute angles—even appearing knife-edged—at the bottom. Fatigue cracks are propagated from each of these notches. It is as simple as that. There is little to support the author's view that the corrosion product "acts as a wedge, forcing the crevice to open a little wider," this effect being repeated until the material finally fractures. In the early stages of corrosion, the induced cyclic strains tend to rupture, or render more permeable, any protective film ; and to dislodge the other corrosion products, so as to expose fresh surfaces of the metal to attack.

On page 15, the author says : "Fretting corrosion may sometimes occur on the surface of tightly-fitting metal parts ; a minute movement may take place between the fittings, due in some instances to one fitting being subjected to fairly severe alternating stresses which are only partially passed on to the other. . . . The movement referred to above causes the surfaces of the materials to roughen and very small particles are torn away which sift out and become oxidised immediately." This hardly conveys the correct impression. The metal parts are supposed to be fitting tightly but are in fact not doing so. There is relative movement, or slip, between them at each reversal of load. If one increases the load sufficiently, the relative movement is prevented, and no fretting corrosion will occur. A number of such examples could be cited. The alternating movement may be caused by vibration. When two surfaces are in contact under sufficient load, they weld together in places. On the reversal of load, the welds break once more. This is how the debris is caused.

Despite these criticisms, the book will be found an invaluable source of reference for all concerned in the subject.

A Textbook of Fluid Mechanics. By J. R. D. FRANCIS, with G. JACKSON. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 24s.

THE title of this book indicates the author's main purpose : to provide a work to which students may refer when they need consolidation or amplification of the material given to them in lectures during the first two years of their degree or similar course in hydraulics. It may be said at the outset that Mr. Francis, clearly an enthusiastic teacher, undoubtedly fulfils that purpose.

His chapters deal, successively, with the properties of ideal and real fluids, with hydrostatics and pressure measurement, with the stability of floating bodies and of vessels containing liquids with a free surface, with definitions concerning fluids in motion, with the plotting of streamlines, with forces due to moving fluids, with the relation between pressure and velocity in moving fluids, and with some applications of Bernoulli's equation. Mr. Jackson's chapter deals with the effect of compressibility in moving fluids—gas flow—and contains an introduction to the analysis of high-speed flow and shock waves. Mr. Francis then continues with chapters on the analysis of experiments in fluid mechanics, on curved flow, on boundary layers, on flow through pipes and flow in open channels, and on some of the simpler cases of unsteady flow. Wherever possible, emphasis is laid on the principles of mechanics, and the mathematical equipment required for a full understanding of the book is less than the content of the usual sixth-form course at school. Most of the illustrations are excellent.

Before starting on his course, Mr. Francis publishes a list of "the pioneers," to remind the student of the men whose names are household words in hydraulic and aerodynamic practice. Mach, a professor of engineering mechanics, would probably be pleased to find himself described as a philosopher, but rumbles have come forth from Henry Darcy's grave : history relates that the great French engineer insisted emphatically on the spelling which one would have expected to come naturally to an English writer, and the second edition of this book should defer to the bearer of the name who, clearly, had every right to reject the pseudo-noble d'Arcy for the near-English Darcy.

In addition to stimulating the student by introducing him to the great pioneers, the author makes it easy for him to test his understanding on a good selection of examples and problems.

What of the practising engineer ? As has been emphasised, the author is a good teacher, and there does not seem to be a better guide available for the man who may never have learned about the modern treatment of the mechanics of fluids, or who feels a need for repolishing his rusty equipment. The author had a choice of presenting a very intricate subject, in which many elegant but—to the engineer—forbidding mathematical methods have been developed, either in a form (occasionally over-simplified) in which it is easy to understand and absorb, or to make the treatment completely rigorous and therefore difficult for the busy or the less confident reader to follow. He has unhesitatingly chosen the first course, and it seems likely that students both at the undergraduate level and in the design office will find this a stimulating and useful book.

Tables for Solving the Laplace Equation Inside an Ellipse. By A. I. VZOROVA. Infosearch, Ltd., London. Distributed by Cleaver-Hume Press, Ltd., 31, Wright's Lane, London, W.8. Price 50s.

THESE tables, the work of A. I. Vzorova, of the U.S.S.R. Academy of Sciences Computing Centre, have been translated by L. Herdan. They are intended for the approximate solution of the first boundary value problem of the Laplace equation,

$$\frac{\partial^2 U}{\partial x^2} + \frac{\partial^2 U}{\partial y^2} = 0$$

in the domain interior to an ellipse,

$$x = a \cos E, \quad y = b \sin E.$$

Books Received

Handbook of the Collection Illustrating Cycles. Part 2. By C. F. Caunter. Science Museum. H.M. Stationery Office. Price 6s.

Thorium Production Technology. By F. L. Cuthbert. Addison-Wesley Publishing Company, Reading, Massachusetts, U.S.A., and Academic Books, Ltd., 129, Queensway, London, W.2. Price 6.50 dollars.

Physical Metallurgy of Uranium. By A. N. Holden. Addison-Wesley Publishing Company, Reading, Massachusetts, U.S.A., and Academic Books, Ltd., 129, Queensway, London, W.2. Price 5.75 dollars.

Boiling Water Reactors. By A. W. Kramer. Addison-Wesley Publishing Company, Reading, Massachusetts, U.S.A., and Academic Books, Ltd., 129, Queensway, London, W.2. Price 8.50 dollars.

The Transuranium Elements. By Glenn T. Seaborg. Addison-Wesley Publishing Company, Reading, Massachusetts, U.S.A., and Academic Books, Ltd., 129, Queensway, London, W.2. Price 7.00 dollars.

Solid Fuel Reactors. By J. R. Dietrich and W. H. Zinn. Addison-Wesley Publishing Company, Reading, Massachusetts, U.S.A., and Academic Books, Ltd., 129, Queensway, London, W.2. Price 10.75 dollars.

Sodium Graphite Reactors. By Chauncey Starr and R. W. Dickinson. Addison-Wesley Publishing Company, Reading, Massachusetts, U.S.A., and Academic Books, Ltd., 129, Queensway, London, W.2. Price 6.50 dollars.

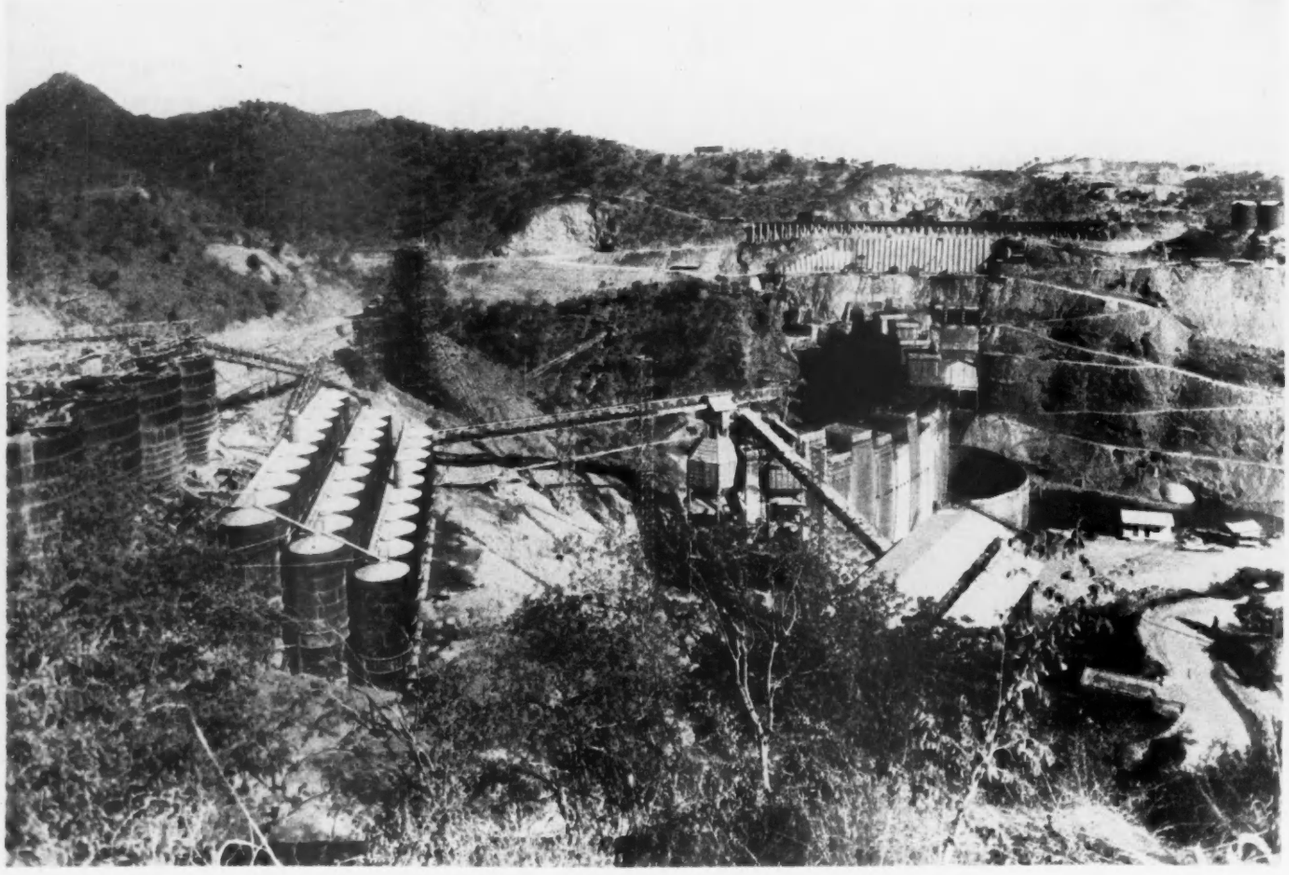
Impounding the Zambesi

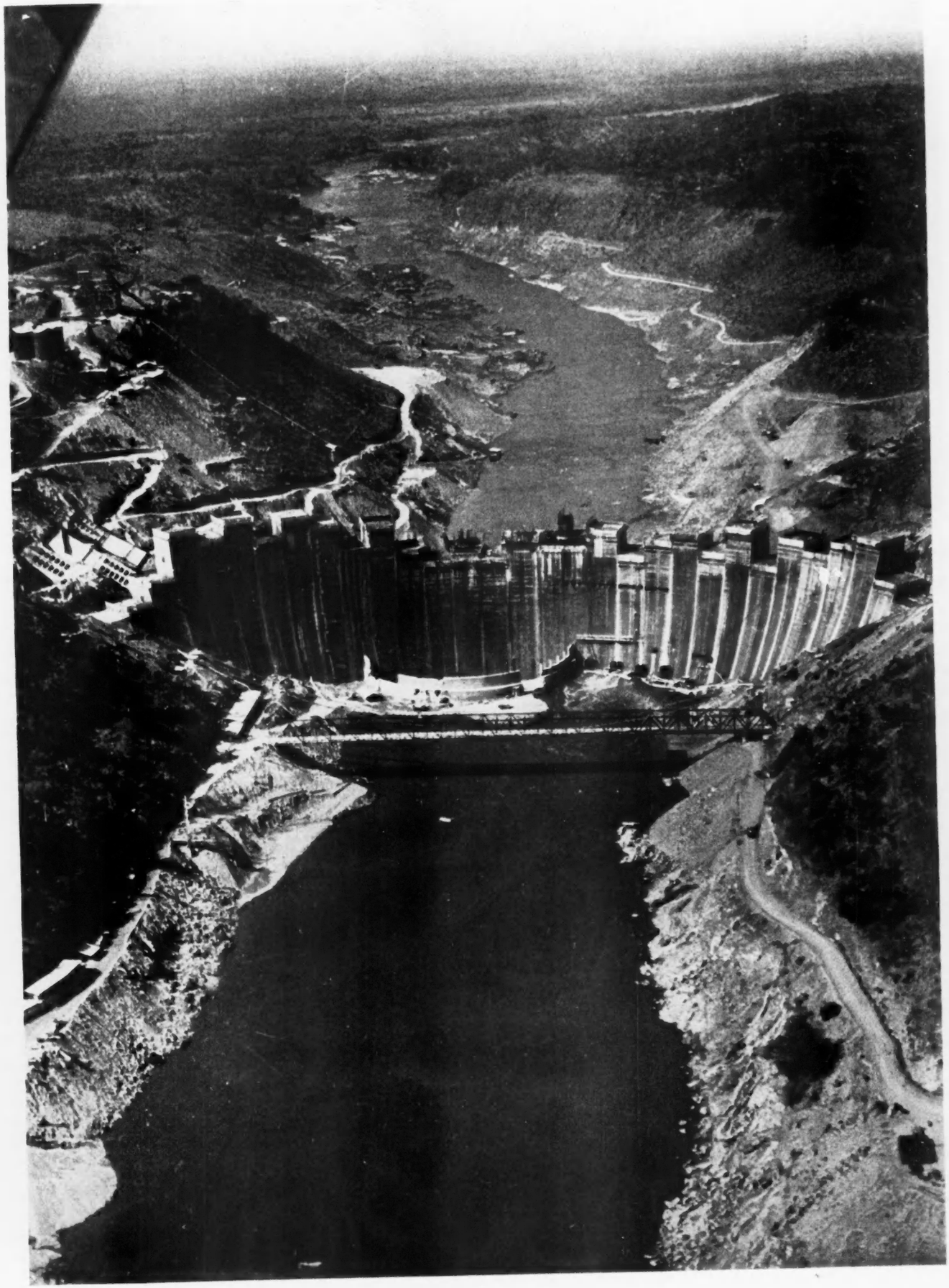
Progress achieved by the beginning of this month in building the Kariba dam is depicted in the illustrations opposite, and at the foot of this page. By contrast, the ACCOMPANYING ILLUSTRATION shows the Kariba site at the end of February of this year, when the river was in flood, and a flow of 450,000 cusecs was reached.

At that time, it was considered that the floods had set back progress by six months, but by last May, so much had been achieved that the contractor promised completion six months earlier than called for by the contract. The stage has now been reached when impounding of the river is due to start. The plug at the upstream portal of the diversion tunnel can be seen on the right of the LOWER VIEW ; the remaining two openings on the left bank side of the dam—clearly shown in the view opposite—are now to be plugged. When this is done, there will only be compensation flow downstream through a 7ft diameter culvert, until 1960, when power will be generated. An explanation of the early stages in construction, and of how the river was diverted whilst the central, circular, cofferdam was built, was given in " The Engineer " of August 3, 1956. The principal data for the scheme were also published then.

In the lower illustration, the track structure for the tail carriages of the cableways can be seen on the far bank, with the three tail carriages on it ; below it is the area prepared for the switchyard and on the other bank is the headmast structure for the cableways. The power station of the first stage works, now under construction, is underground immediately below the switchyard, and the power station intakes can also be seen in the lower view. The lowest intakes are temporary, for operation at a reduced head before impounding is completed (the reservoir has a total capacity of 150 million acre-feet at flood storage level of 1605ft). The upper intakes have an invert level of 1510ft, the normal top water level at the final stage being 1590ft. Two concrete batching and mixing stations, with their associated silos and conveyors, are also prominent in the lower view. The VIEW OPPOSITE shows reinforcement in position in the central part of the dam, where there will be six flood sluices. Note also the area cleared for the reservoir, which will extend upstream for about 2000 square miles.

The Kariba scheme will eventually have 1200MW of power installed, and a firm power output of over 8×10^9kWh. It is administered by the Federal Power Board of the Federation of Rhodesia and Nyasaland. There are four consulting firms—two French and two British—responsible to the Board. The three civil engineering consultants, of which the British firm is Sir Alexander Gibb and Partners, have formed a local organisation known as Gibb, Coyne, Sogei (Kariba) (Pvt.), Ltd., and the electrical and mechanical consultants are Messrs. Merz and McLellan. The main civil engineering contractor is Impresit (Kariba) (Pvt.), Ltd., a consortium of four Italian contracting firms and their African associates.

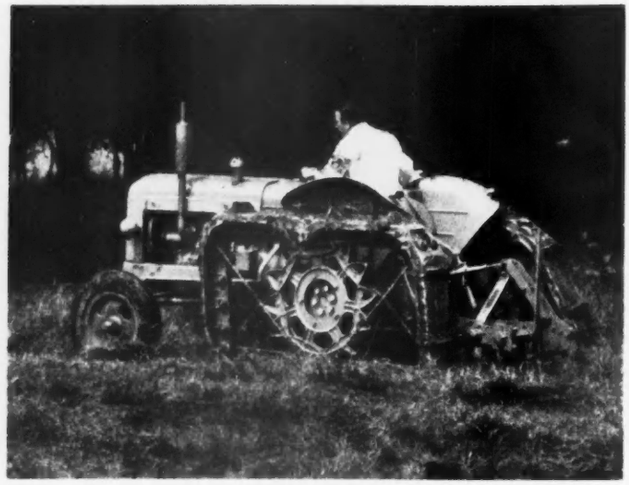




Farm Machinery at Earls Court

No. II—(*Concluded from page 891, December 5*)

The Smithfield Show and Agricultural Machinery Exhibition which opened at Earls Court on Monday and closes this evening, has drawn a large attendance of visitors from this and many other countries. The machinery exhibits appear to be more numerous than ever. Here, we conclude our survey of these exhibits by referring to a few of the many agricultural engineering developments to which the show directs attention.



IN our last issue, we described a few of the tractors which are exhibited at this year's Smithfield Show. They indicate improvements in design and utilisation which manufacturers continue to make. The subject of improvements in the design of tractors and other farm machines was mentioned by Mr. W. H. Cashmore, director of the National Institute of Agricultural Engineering, in a paper which he presented last week to the Farmers Club. He emphasised that the tractor was an efficient and reliable source of power, and went on to express the view that, in the future, an even wider range of forward speeds would be required. Mr. Cashmore hinted at the possibility that wheeled tractors would gradually replace some of the tracklayers on account of the high rate of track maintenance, and thought also that four-wheel drive tractors seemed desirable. Other "advantages" mentioned in the paper were power-assisted steering for the larger models and, for work in hilly districts, some form of safety cab to reduce accident risk.

It is evident from the tractor exhibits at the show that many of the improvements to which Mr. Cashmore referred are already being incorporated in current designs. At the same time, there is no decline in the number of track tractors exhibited. There are also several examples of cage wheels and track equipment which can be applied to wheeled tractors for work in adverse weather and other arduous conditions. One such example is the "Rotaped" half-track exhibited by Leeford (London), Ltd., 33, Upper Brook Street, London, W.1, and shown in our title illustration. The track links are high duty light-alloy castings, the average track width being 11½in; the alloy steel rails are anchored by screws and the case-hardened rollers are held by circlips for speedy interchangeability. The chain sprockets, which are precision cast, run on needle bearings, and the rim of the driving wheel casting is hardened to resist wear; the fourteen tooth segments are surface-ground castings. It is stated that changing over from pneumatic-tyred wheels to the "Rotaped" half-tracks can be accomplished quite quickly, sprockets being attached to the tractor axle in much the same way as the wheels. The makers claim that this half-track equipment can increase drawbar pull by over 100 per cent and reduce ground pressure by 85 per cent.

Tillage Implements

On various stands there may be found examples of design improvements in both mouldboard and disc ploughs. The plough is still the principal tool for basic cultivation. One of the new implements shown by Massey-Ferguson (Great Britain), Ltd., Coventry, is a two-furrow 12in reversible mouldboard plough. As indicated in an accompanying illustration, the plough is mounted on the three-point linkage of a tractor. Its movement is hydraulically controlled, the plough rotating through 180 deg. The controls are easily accessible from the tractor seat; they consist of a lever for actuating the "roll-over" mechanism and two handscrews for adjusting the lateral tilt of the plough.

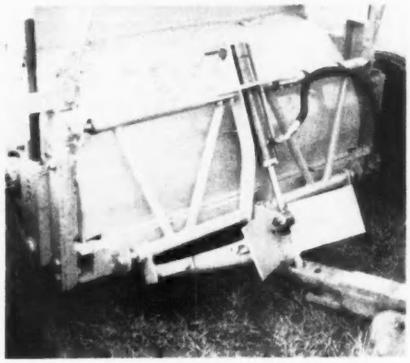
There are three new ploughs on the stand of David Brown Industries, Ltd., Meltham, Huddersfield; they are in the David Brown Albion range of implements made by Harrison, McGregor and Guest, Ltd., Leigh, Lancs. One of them is, in effect, a conversion set enabling a standard 3/2 furrow mounted disc plough to be quickly adapted to mouldboard ploughing. The conversion is effected by removing the disc assemblies and replacing them with 10in mouldboard units which are bolted to the steel triangular main frame of the plough. The other new David Brown Albion implements are a two-furrow reversible disc plough and a two-furrow "alternating" mouldboard plough which can be changed over easily from right to left-hand working. The same firm is exhibiting a rear-mounted pneumatically operated toolbar for the David Brown 2D tractor (the latest version of which was described in THE ENGINEER of July 4 last). The tractor's inbuilt pneumatic system, which is provided for operating mid-mounted implements, also operates the rear lift, there being an additional ram, with a capacity of 300 lb, at the back of the tractor.

Another new reversible plough is that which has been developed recently by Bomford Bros., Ltd., Pitchill, near Evesham. This implement has been designed in support of the view taken by many agriculturists that weed control is the most important function

Massey-Ferguson "797" two-furrow reversible plough. This implement can be rotated hydraulically through 180 deg.

The Bomford reversible plough has been designed to assist weed control; the share clearance "tip-to-tip" is 35in

of ploughing. To that end it is necessary to bury all the surface soil and weeds to the full depth of the ploughing. After a good deal of experiment, the makers found that their objective could not be reached without a share clearance tip-to-tip of at least 35in in a multi-furrow plough. This arrangement is illustrated herewith. The principal problem



The "Manners" hydraulic hitch for coupling a forage harvester collecting trailer

in designing a two-furrow mounted reversible plough with that clearance was to keep the weight down without detracting from the strength of the implement. The design finally adopted provides for a single steel tubular beam and two straight-through tubular legs. A simple reversing gear based on the principle of "gained motion" turns the implement over.

Harvesting Machines

Throughout the exhibition there are numerous examples of machinery for harvesting corn, hay and green crops. They include, of course, combine-harvesters for dealing with all kinds of grain crops. There are grass mowers which can be mid-mounted or rear-mounted on a tractor, and there are many forage harvesters. Recently, there has been a prodigious increase in the number of these last-named machines. They are an essential part of the equipment needed for green crop conservation or silage making. The majority of them are "flail" machines, that is, they incorporate a number of swinging steel flails assembled on a dynamically-balanced rotor. The action of these flails literally tears off the green crop, lacerates it to some extent, prior to forcing it up a delivery chute. One example of the many machines of this kind is a new model, made by Lundell (Great Britain), Ltd., Lingfield, Surrey, which has a cutting width of 40in. It can be operated by tractors of 20 h.p. upwards. The rotor carries twenty high tensile steel flails, each with a cutting width of 2½in but overlapping to give the total cut of 40in. The sheet steel delivery chute, which is 7ft 6in high, is fitted with an adjustable deflector so that the cut material can be loaded into any position in the trailer which is hitched to the back of the harvester.

Another forage harvester with flails which give a total cutting width of 40in is the "Sila-Masta," built by John Wilder, Ltd., Wallingford, Berks. A new piece of equipment shown with this machine is a hydraulic hitch designed to reduce the time and manpower needed for the business of connecting and disconnecting the collecting trailer behind a forage harvester. Normally, a forage harvester will load a trailer in from ten to fifteen minutes; the change-over of trailers usually requires two men. It is claimed that this hydraulic hitch, which is the invention of Mr. W. Manners, of Darlington, reduces the time for changing over from one trailer to another to about thirty seconds. An accompanying illustration shows the arrangement. To couple up the trailer, the tractor driver backs the harvester, roughly positioning its centre to the trailer drawbar. The guide plates on the hydraulic lift are wide enough to allow for steering errors while backing; these plates centre the trailer drawbar, so that the drawbar ring is automatically located over the hydraulically operated hook. The driver then operates the tractor's hydraulic pump to lift the hook into the drawbar ring and to lift the drawbar itself into its final position behind the harvester. To uncouple the trailer, the drawbar is lowered by releasing the tractor's hydraulic pressure and a slight backward movement of the tractor and harvester presses the hook downwards out of the drawbar ring.

An unusual item of hay-making equipment is one of the new machines exhibited by Bamfords, Ltd., Uttoxeter, Staffs. It is appropriately called a "Wuffler" and is used for the conditioning of mown hay. One of our illustrations shows the machine with its hood removed; it is operated by tractor power take-off, the vee belt drive being taken from the p.t.o. drive pulley to the larger pulley at the end of the tine drum. The machine is assembled on a fabricated steel frame and the working height of the spring-loaded tines is controlled by a turnbuckle on the drawbar. The hood of the "Wuffler" is fitted with adjustable doors at the back, the purpose of which is to deflect the crop into neat rows after it has passed through the machine.

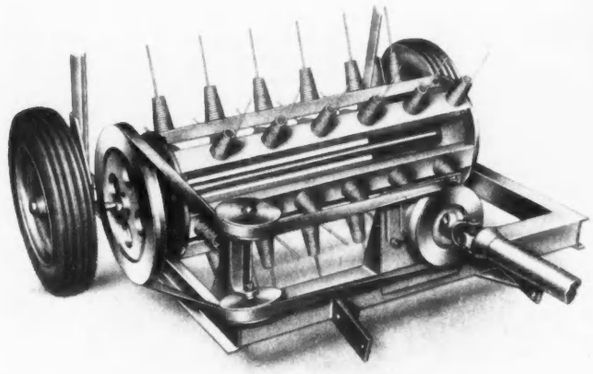
Irrigation Equipment

Crop irrigation equipment has a place in the show. Wright Rain, Ltd., Crowe, Ringwood, Hants, is exhibiting an irrigation indicator which combines the function of a rain gauge with an evaporation pad that "transpires" at the same rate as growing plants. The indicator shows on a sight glass the current moisture deficit of the soil.

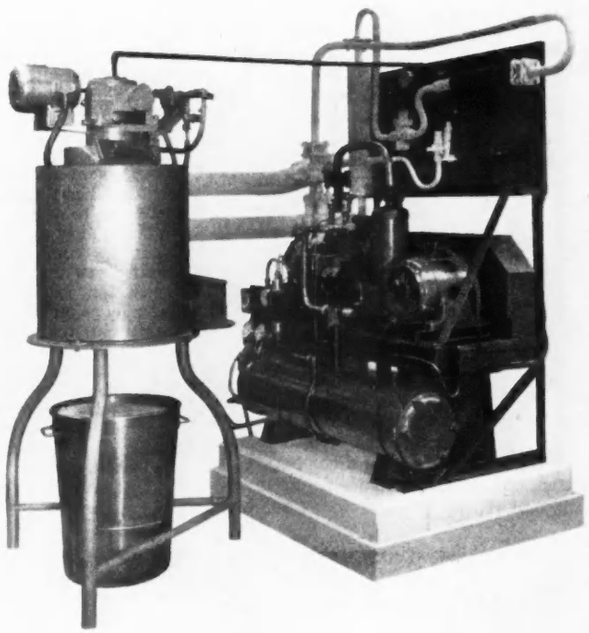
Another new item is the Armfield "Maxiflow" propeller pump for flood irrigation and drainage work. This 10in diameter pump, which is driven by tractor power take-off, is mounted on two pneumatic-tyred wheels fitted to its frame, and is claimed to be capable of moving 1,000,000 gallons of water in six hours. A coarse strainer is fitted to the intake to protect the pump and pipeline from stones and other matter which may be sucked in; the complete suction pipe is fitted with a quick-release device so that the pipe can be easily removed should the strainer become clogged with weeds. It is stated that the most useful performance of the pump is achieved at impeller speeds of 1350 to 1750 r.p.m. As that speed is greater than the maximum p.t.o. speed of most tractors, a speed increasing gearbox can be incorporated in the pump.

Wright Rain, Ltd., includes also in its irrigation equipment a tractor-mounted p.t.o. driven irrigation pump which uses the flow of water to cool its integral gearbox. It is suitable for any sprinkler irrigation scheme up to 100 acres.

A centrifugal, self-priming pump, suited to many agricultural and horticultural duties, is the "Alcon 3" exhibited by Arthur Lyon and Co. (Engineers), Ltd., 6, Carlos Place, London, W.1. It is powered by a Lister L.D. I air-cooled diesel engine which develops 3·5 h.p. at 1800 r.p.m. The pump is spigot-mounted directly on to the engine crankcase,



Tractor-operated "Wuffler" for hay or green-crop conditioning



Flake ice machine

with the three-bladed impeller fitted to the extension to the crankshaft. Efficient priming is obtained by the use of adequate recirculation passages and a large chamber for the separation of air and water. The pump, the output of which is put at 12,000 gallons an hour, is mounted with its engine on a bed-plate which can be fitted, if required, with a rubber-tyred two-wheel trolley.

Some Other Exhibits

There are many examples of "miscellaneous equipment" at the Smithfield Show; equipment which is being used increasingly by farmers as well as in other directions. There is, for instance, a flake ice machine, illustrated herewith, exhibited by J. and E. Hall, Ltd., Dartford, Kent. The refrigerant occupies the annular space between the double walls of a vertical freezing drum, and cools the inner surface. A smooth and uniform flow of water is maintained from a water header at the top, on to the chromium-plated freezing surface, where it forms a sheet of ice. The only moving part of the flake ice-maker is a rotor arm carrying the blades which remove the ice. Just before the blades crack the ice and dislodge it the water flow stops, and the ice becomes super-cooled and dry, so that when dislodged by the rotor blades it falls freely from the drum into a collecting bin below the machine. The water that has not been converted into ice is aerated in the water system before it is returned to the water header, and thence back to the freezing surface. Flakes produced by this process are of irregular shape, averaging 1in square and $\frac{1}{16}$in to $\frac{1}{8}$in thick. The machine is suitable for use with Refrigerant 12 (Arcton 6, Freon 12), ammonia, brine or any other convenient refrigerant.

The "Gopbro" mobile swing saw, suitable for estate and forestry work, is shown by Jeffery Engineering Company, Ltd., St. Oswald's Road, Gloucester. This machine for which a bronze medal was awarded in the Royal Agricultural Society's recent competition for forestry equipment, is powered by a 420 c.c. B.S.A. petrol-paraffin engine. Its 24in diameter circular saw blade revolves in a twin roller head which is vee-belt driven. A steel casing covers the saw blade. Depression of a foot pedal swings the saw out of the casing into work, the timber to be dealt with being fed on to a steel tray attached to the saw casing. The saw is said to be capable of taking timber up to 9in in diameter.

An air compressor designed for attachment to the rear linkage of a tractor is one of the exhibits of Romac Industries, Ltd., The Hyde, London, N.W.9; it is flexible shaft-driven from the power take-off and is available in capacities of 22 and 40 cubic feet per minute. Both models will operate equipment such as hedge-cutters and the 40 cubic foot model can be used as well for operating heavy pneumatic tools.

Conclusion

Our visits to Earls Court this week have again left us with the thought that it would be fitting to change the title of the "Smithfield Show and Agricultural Machinery Exhibition." We have been impressed, as, we feel confident, have the many thousands of other visitors from home and overseas, by the excellence of the cattle and sheep. But it would be difficult indeed not to be more impressed by the machinery exhibits! Stock raising is still an important part of British farming, but stock raising and arable farming alike become more and more dependent upon mechanisation if they are to be efficiently undertaken. It is now well over a hundred years ago since the show was held in the neighbourhood of Smithfield. We readily acknowledge that there is much of value in tradition, but we nevertheless feel that the real emphasis of this exhibition would be more quickly appreciated if its title was now changed to, say, "The Farm Machinery and Cattle Show."

WELDED ALUMINIUM STORAGE TANKS

BY OUR SOUTH AFRICAN CORRESPONDENT

WHAT is believed to be the largest job of welded aluminium tank fabrication ever undertaken in South Africa has recently been completed by Harry T. White (Pty.), Ltd., of Pietermaritzburg. The tanks were required for chemical processing and for the storage of acetic acid, vinylacetate-monomer, corrosive intermediary products and chemical auxiliaries at the new plant of Holland Electro Chemical Industries (Pty.), Ltd., at Ballengeich, Natal. For the greater part of this plant Acosa 99·5 per cent minimum purity aluminium was used as the construction material, as it is cheaper and lighter than stainless steel and as its resistance to corrosion was found to be extremely satisfactory. Welding of the tanks was undertaken using a 10A to 700A portable argon arc welding set. Aluminium plate was supplied in thicknesses varying from $\frac{3}{16}$in to $\frac{3}{8}$in and in sizes up to 17ft by 3ft. One of our illustrations shows an operator welding a seam on a $\frac{3}{8}$in plate. The electrode welding rods used were also of 99·5 per cent purity.

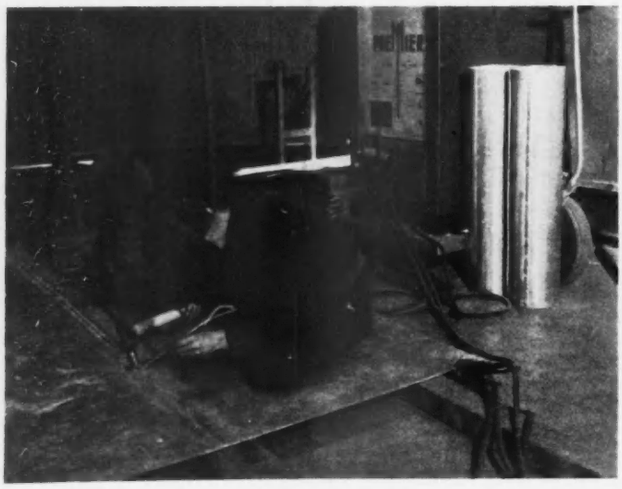
As this was the first large all-welded aluminium contract handled by Harry T. White, it was necessary to carry out some experimental work in edge preparation of the plates. After various trials, the company found the use of portable electric saw and suitable lubricant an entirely satisfactory method and easier than circular saw bench edge preparation.

Most of the vessels were flat-based, vertical, cylindrical units, with inverted conical enclosed tops incorporating a central manhole opening. Manhole necks were flanged outwards and fitted with a loose heavy mild steel drilled flange. The tops and bottoms of the tanks were radiused, which allowed circumferential welded seams to be located on the cylindrical body away from the radiused corner. The radiusing of the end plates was undertaken by hand on preset adjustable jigs, which ensured uniformity of flanging. The actual rolling of the cylindrical bodies was accomplished on a three-roll forming machine. In all, twenty-seven tanks were constructed, ranging in size from 200 gallons to 3300 gallons capacity, as well as a number of smaller aluminium drums of about 50 gallons capacity. One of the 3300-gallon tanks is illustrated.

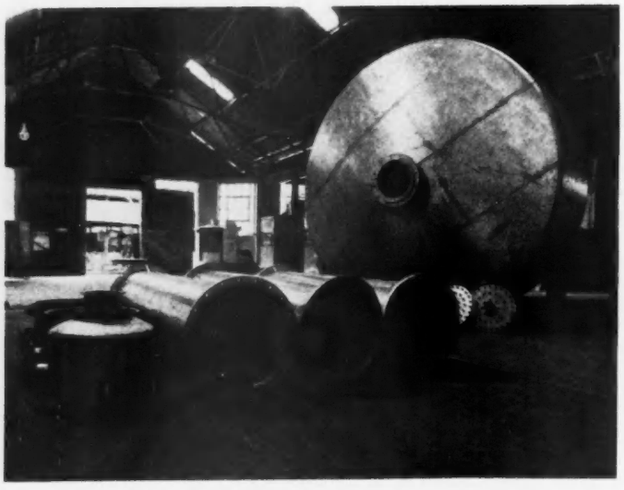
In addition, the company manufactured a number of aluminium condensers, also of the same purity metal. For the condensers extruded tube was used. The tube plates were drilled and holes flanged outwards to allow the tubing to be edge welded by the argon arc equipment. The condensers were subjected to 30 lb per square inch test pressure.

Testing of welds was undertaken by the Aluminium Company of South Africa (Pty.), Ltd., in their plant laboratories at Pietermaritzburg. Samples were taken from the work, and tensile tests, notch fracture tests and etch tests made. The tensile tests were made to determine the ultimate tensile strength and elongation of the welded parts. The lowest ultimate tensile strength on the series was 9850 lb per square inch, which is well above the guaranteed minimum figure of 8960 lb per square inch set by British Standard Specification for 99·5 per cent aluminium. The notch fracture and etch tests showed the degrees of penetration and fusion and enabled the operators to maintain control of the welding technique. Welded seams were all left as welded and not dressed.

The construction of this chemical processing equipment was the largest aluminium contract ever carried out by the fabricators, who report that it was, to a great extent, different from all previous aluminium fabrication they had undertaken. They express the opinion that there is a great future for the fabrication of aluminium.



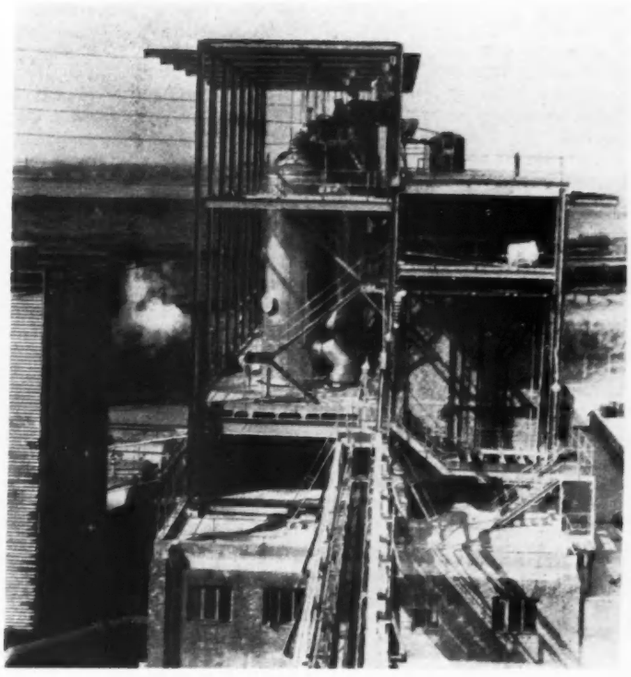
Operator in process of welding a seam on a 5in, 99·5 per cent purity aluminium plate



One of the 3300-gallon aluminium tanks, with parts of an aluminium processing column in the foreground

Hydrogen Peroxide Works at Warrington

Increasing demand for hydrogen peroxide for traditional uses and also as a propellant has resulted in research to develop new and cheaper methods of manufacture. A new process has been evolved by Laporte Chemicals, Ltd., and a plant to manufacture hydrogen peroxide by the new method has been built at the company's Baronet Works, Warrington. On the right is an illustration of the distillation section of the plant, while below is a general view from the east showing the oxidation, hydrogenation and extraction stages of the process.

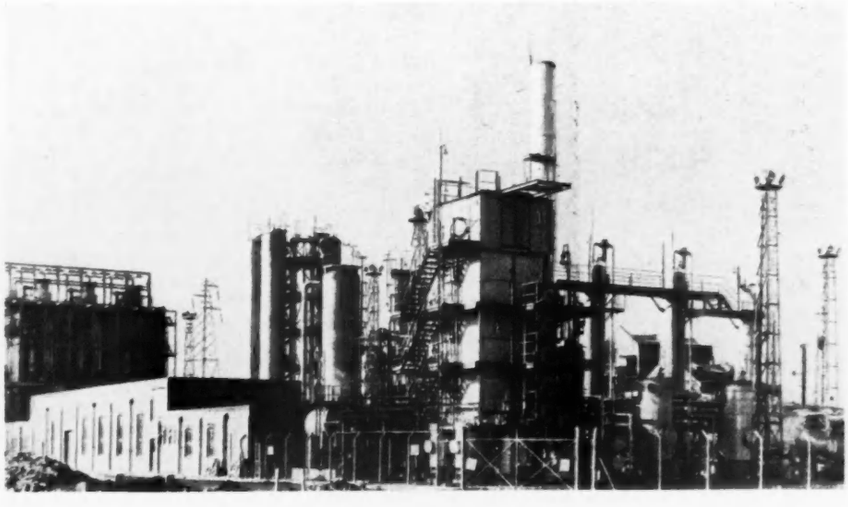


TUESDAY, November 25, marked the official opening of the A.O. Hydrogen Peroxide Plant which has been built at the Baronet Works, Warrington, of Laporte Chemicals, Ltd., and which will double the company's output of high-strength hydrogen peroxide, known as High Test Peroxide (H.T.P.). Production is by a new process designed greatly to reduce manufacturing costs, and which has been developed by the Laporte central research department, while the design has been the responsibility of the group's engineering construction department.

It is of interest to note that after the control schemes and vessel sizes had been determined the operating characteristics of the plant were obtained by setting up a representation of the process on an analogue computer. An EMIAC I computer was used and attention concentrated on the mass flow of liquids round the circuit: a series of equations representing conditions controlling flow at all points was fed into the computer on a time scale compressed by a factor of 60. The resulting information enabled the design work to proceed since it confirmed that no major errors had been made either in vessel capacities or in the control systems.

The plant occupies a triangular site on the nothern side of the works and has been largely built in the open, the main constructional material being aluminium and its alloys, with the joints being argon arc welded. This has involved special techniques since the thickness of the material involved often exceeded 1½in. Many of the vessels are of large size, the columns ranging in height up to 80ft and in diameter up to 12ft.

Control of the plant is from a central panel, housed in an air-conditioned services block, and divided into three sections, namely: a graphic representation of the plant with miniature instruments indicating values of flow, levels, &c., an alarm section, and a conventional section with instruments recording temperatures, gas analyses and tank contents. Wherever possible pneumatic instruments have been employed to avoid risk of fire. Control valves range in size from ½in bore, bellows seal, single seated valves, up to 10in double seated stainless steel units, and all have P.T.F.E. glands.



Hydrogen peroxide plant viewed from the east

The early German process used as an intermediate 2-ethyl anthraquinol which in solution was auto-oxidised, yielding hydrogen peroxide and quinone, and the latter, after separation of the hydrogen peroxide by aqueous extraction, was catalytically hydrogenated to the quinol and the solution recycled. This process has been developed by a number of companies including Laporte Chemicals, Ltd., and that adopted for the new plant at the Baronet Works is based on the use of 2-ethyl anthraquinone.

Supplies of hydrogen are provided by a plant manufactured by the Power Gas Corporation, Ltd., in which butane from the Stanlow oil refinery is cracked in the presence of steam and a catalyst to yield hydrogen and carbon monoxide. The latter is removed by reacting with steam over a catalyst to give hydrogen and carbon dioxide, which is removed by scrubbing with monoethanolamine and later used as a purge gas in the autoxidation process. The carbon monoxide content of the hydrogen is further reduced by the formation of methane and the hydrogen is then compressed in Broom and Wade single-stage, double-acting dry cylinder machines capable of delivering 400 cubic feet per minute at 50 lb per square inch gauge.

Two identical units which operate in parallel up to the extraction stage, where the solution from both streams mixes, form the autoxidation process organic cycle and are mounted either on concrete slabs or in concrete bunds. Hydrogenation is carried out using a catalyst, palladium on an inert support, in free suspension in a stream of hydrogen. The catalyst is added to the reactor as required to maintain the rate of reaction and the hydrogenated solution passes through filters which retain the catalyst. Both the oxidation and hydrogenation reactions are exothermic so that the filtered solution is cooled before passing to the oxidisers into which it is fed at the base together with air. Howden high-speed rotary

compressors supply the air and are capable of delivering 3000 cubic feet per minute at 40 lb per square inch. The gas/liquid mixture leaves at the top of the reactor and the excess air, before passing to atmosphere, is passed through a solvent recovery plant, supplied by the British Ceca Company, Ltd., which consists of four vessels packed with activated carbon, two of which are in line at one time.

Columns fitted with perforated plates and employing contra current flow are used to extract the hydrogen peroxide from the organic solution. This is fed into the base of the column while the aqueous feed, admitted at the top, is de-ionised water containing a stabiliser and a corrosion inhibitor. The aqueous product contains about 20 per cent hydrogen peroxide and after the removal of dissolved organic compounds is held in run down tanks for a quality check. The extracted organic solution passes to storage and is returned to the hydrogenator.

In general the hydrogen peroxide is further purified and concentrated by distillation to 50 to 90 per cent hydrogen peroxide. The vaporisers are of vertical tube and shell pattern with recirculation, the vapour/liquid mixture passing to a separator. There are three stills and the vapour is fractionated in columns using direct reflux, one column being fitted with West plates and the others being packed with ceramic rings, to yield a product at the desired level of concentration in the range 50 to 70 per cent hydrogen peroxide. The overhead product, mainly water vapour, is condensed by jet spray condensers, and part of the production from the stills is converted to 85 to 90 per cent hydrogen peroxide.

The contractors included : Boulton and Paul, Ltd., Babcock and Wilcox, Ltd., Head Wrightson Processes, Ltd., Matthew and Co., Ltd., Musgrave and Co., Ltd., Newalls Insulation Company, Ltd., Permutit Company, Ltd., C. A. Parsons and Co., Ltd.

Data for Southern Outfall Works, Crossness

Present dry-weather flow, m.g.d.	90
Present average daily flow m.g.d.	96
Present population served	1,600,000
Drainage area, acres	44,400
New sewage pumps :	
Low level sewers to treatment plant, m.g.d.	151·2
High level sewer No. 2 to treatment plant, m.g.d.	64·8
Low level sewers to high level sewer No. 2, m.g.d.	64·8
Storm tanks :	
Number	6
Total capacity, gallons	23,230,000
Detritus Channels :	
Number	3
Length, ft	325
Constant velocity	1ft per sec
Total capacity, gallons	1,200,000
Primary sedimentation tanks :	
Number	16
Total capacity, gallons	20,700,000
Total surface area, square ft	276,000
Aeration tanks (Simplex type with high intensity cones) :	
Number	16
Total capacity, gallons	30,720,000
Aerating cones	384
Final sedimentation tanks :	
Number	32
Total capacity, gallons	22,934,000
Total surface area, square feet	294,000
Sludge pumping station :	
Primary sludge maximum pumping rate, g.p.d.	4,950,000
Returned activated sludge pumping rate, g.p.d.	96,000,000
Power house :	
Ten dual-fuel-engine-driven alternators, capacity of each	800kW
Voltage	6·6kV
Sludge digestion tanks :	
Number of primary tanks	16
Total capacity, tons	58,300
Detention	2 weeks
Gasholder capacity, cubic feet	440,000
Surface area, square feet	80,000
Number of secondary tanks	12
Total capacity, tons	85,000
Detention	3 weeks
Estimated gas production, cubic feet a day	1,290,000
Sludge booster station (delivering to ships) :	
Maximum pumping rate, tons per minute	70

L.C.C.'s Southern Outfall Works

The London County Council has in hand a major programme of construction for the purification of sewage at its two main outfalls, which serve the northern and southern banks of the Thames respectively. The new works at the Northern outfall are now at an advanced stage, and have been described in these columns on several occasions. Here we give details of the general layout and construction of the Southern Outfall development.*

EXTENSION of the London County Council's Southern Outfall Works at Crossness, Erith, has now been in hand since April 21, 1958. To date extensive earthworks and piling have been carried out and excavation for the sewage pumping station is nearly complete. Construction is scheduled to be completed by April, 1963, and the plant is due to be in operation six months earlier. The total estimated cost of the extension, including structural, mechanical and electrical contracts is £9,750,000, of which the tender for the main civil engineering and building accounts for £6,841,366.

The new treatment plant has been designed to deal with an average flow of 96 m.g.d. ; it serves a population of 1,600,000 people and a drainage area of 70 square miles, of which 12 square miles are outside the County of London. It will consist of a screen house, sewage pumping station, detritrus channels, primary sedimentation tanks, aeration tanks, final sedimentation tanks and sludge digestion plant, arranged as shown on the accompanying plan. The existing pumping plant and sedimentation tanks will remain in use for dealing with storm water flow. Further data about the Southern Outfall Works is given in the accompanying table.

The flow from the existing two low level sewers and one high level sewer will be intercepted at the combined screen house and pumping station. The whole of the incoming flow will be dealt with by six low level and four high level automatically-operated screens and flows up to 216 m.g.d. will be pumped to the new works for full treatment. There will be ten " duty," plus two " standby " vertical-spindle electrically-driven sewage pumps, and it is intended that operation shall be fully automatic.

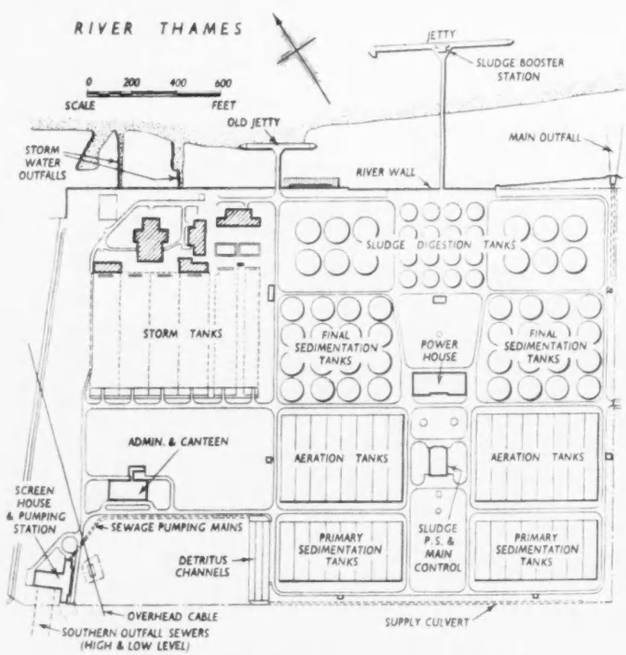
After passing through constant velocity detritus channels the sewage will be distributed to sixteen rectangular primary sedimentation tanks arranged for mechanical removal of sludge. Following primary sedimentation the sewage will be treated by the " Simplex " surface aeration method and thereafter the flow will pass to thirty-two final sedimentation tanks of 113ft diameter, where the activated sludge will be removed. Removal of sludge will be mechanical in these tanks as well. The treated effluent will be discharged through a reinforced concrete box culvert to a new outfall on the River Thames.

The sludge from the primary sedimentation tanks will be maintained at a temperature of 85 deg. Fah. and digested in sixteen primary sludge digestion tanks of 80ft diameter, covered with gas-holder roofs. After further treatment in twelve secondary sludge digestion tanks (which will be open and unheated) where a large proportion of the water content will be decanted, the sludge will be delivered by twin mains to two loading positions on a new jetty built 600ft out into the River Thames. The jetty has been designed to accommodate larger sludge vessels which may be acquired in the future, as well as the Council's present fleet.

Ten dual-fuel-engine-driven alternators (inclusive of two stand-by sets) will supply electric power to the works. Fuel may be sludge gas or diesel oil, and it is expected that the sludge gas production, estimated at 1,290,000 cubic feet per day, will be sufficient to power four sets. A sludge pumping station for both raw and activated sludge will be near the centre of the works and the same building will contain a control room with a main meter panel and remote controls. Other buildings ancillary to the works will include administrative offices.

The work is being carried out under the direction of the Council's Chief Engineer, Mr. J. Rawlinson, C.B.E. The structural design has been undertaken by W. C. Andrews and Partners, consulting engineers, and the associated architectural work has been the responsibility of the architect to the Council, Mr. H. Bennett, F.R.I.B.A. The main civil engineering contractor is W. and C. French, Ltd.

Various mechanical and electrical engin-



Plan of the new works at the L.C.C.'s southern outfall at Crossness

* See THE ENGINEER, April 19, 1957 and July 1, 1955.

eering contracts have been let as follows : Ames Crosta Mills and Co., Ltd., for surface aeration plant and final sedimentation desludging equipment ; R. and J. Dempster, Ltd., for gas holders ; Dorr-Oliver Company, Ltd., for sludge digestion heating and circulating plant and for final sedimentation desludging equipment ; Hartleys (Stoke-on-Trent), Ltd., for primary sedimentation desludging equipment and for detritus pumps ; Sigmund Pumps, Ltd., for sludge booster pumps ; S. S. Stott, Ltd., for screens , and The English Electric Company, Ltd., for power plant. The London Electricity Board was responsible for the diversion of electric cables.

Refuse Disposal Works at Glasgow

A refuse disposal works opened recently at Polmadie Road, Glasgow, is stated to be one of the largest of its kind in the country. Built at a total cost of some £1,668,000, it is capable of handling 400 tons of crude refuse per eight-hour shift, and the equipment in the disposal plant building is installed in four similar independent sections.

A NEW refuse disposal works which has been opened at Polmadie Road, Glasgow, is designed to handle 400 tons of crude refuse per eight-hour shift. The refuse disposal plant itself comprises four independent sections, each with a capacity of 100 tons per shift, and under normal working conditions three sections are used with the fourth acting as a stand-by for peak load conditions. This plant has cost some £1,250,000 and the scheme also includes a garage block costing £70,000, as well as a vehicle repair shop, amenities block, boiler house, &c., costing some £268,000. The complete works has been supplied and built to the designs of the principal contractors, Heenan and Froude, Ltd., of Worcester, and the consultants for the works were Merz and McLellan, of Newcastle upon Tyne.

The clean, modern design of the works can be seen from one of our illustrations, showing the main buildings from the approach side. Incoming vehicles full of refuse enter the reception bay on the second floor of the building via the inclined approach road and dump their contents into one of four large steel hoppers along one side. Plate feeders in these hoppers deposit the refuse on to conveyors, which elevate it to primary rotary screens. These screens separate material under 1½in, and this material is taken by belt to secondary screens where dust and cinders are removed. The cinders are passed over garbage separators for screening, and the remaining débris can be fed either on to tailings belts or to dust conveyors.

Facilities are provided for the initial removal and transfer of very bulky material, trade waste and separately collected paper. On the main sorting floor salvaged materials are recovered from horizontal picking belts on to which the rejects from the primary screens are deposited. One of the four recovery belts can be seen in our second illustration. Salvage recovered from these belts is dropped into storage bins, whilst tins and ferrous metals are withdrawn either by overband electro-magnetic separators which bridge the belts or by magnetic pulleys at the heads of the conveyors taking screenings from the primary to the secondary screens. The tins are deposited into hoppers on the floor below, whence they are transferred to a baling machine by hand. Paper picked from the belts is delivered to a central station for further sorting before baling.

Refuse or "tailings" remaining on the belts after sorting is conveyed to a belt system serving the incinerator floor, shown in our second illustration. This belt system is mounted above the incinerator lines and is designed to feed refuse into any selected incinerator, final discharge into individual grates being effected by a shuttle conveyor. Each of the four incinerator installations has five grates which are equipped for hydraulic clinkering. Each grate is supported on a carriage and at the required intervals it is withdrawn completely by hydraulic power to allow the clinker to gravitate to a skip beneath, where it is quenched by water sprays. Each of the four clinker skips serving the incinerator lines operates in a closed tunnel from which the fumes are drawn into the furnace. These skips are controlled by push buttons on a central panel and an electrical interlocking arrangement ensures that a grate cannot discharge unless a skip is in the correct position below. At the completion of quenching the skip traverses along to a storage hopper, discharges its load and returns to a parking position ready for the next clinkering cycle. A separate plant with a capacity of 3 tons an hour provides for the crushing, screening and grading of some of the clinker which is produced.

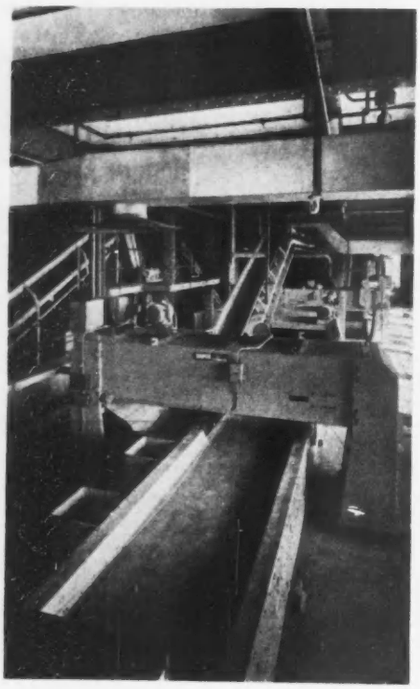
To prevent pollution of the atmosphere in the vicinity of the plant, gases from the incinerators are passed through grit collectors of multi-vortex design, which incorporate an induced draught fan, centrifugal primary and

Refuse disposal plant with inclined approach road for vehicles to second floor of main building

Conveyors delivering refuse to one of the four incinerator lines

secondary collectors and a grit settling tank. Automatic equipment is incorporated to ensure a constant depression in each incinerator combustion chamber. In this equipment a hydraulically-operated suction governor connected to the chamber controls the speed of the main induced draught fan through the medium of a Heenan "Dynamatic" coupling. The cleaned gases from the four incinerator sets are delivered into two 220ft high reinforced concrete chimneys.

Throughout the whole of the main building particular attention has been given to the maintenance of clean, dust free atmospheric conditions, and extraction fans exhausting to filters are connected to numerous points in the refuse handling, screening and salvage plants. The central portion of the main building is heated by eight units in which air drawn from outside by a fan is passed through steam-heated tubular coils. Low-pressure steam is supplied for the coils by a boiler fired by cinders recovered from the plant. When required, air from within the building can be recirculated through the heating units to save cold air being drawn from outside.



Salvage floor, showing one of the picking belt conveyors and overband magnetic separator for removal of tins

As already mentioned, the whole plant comprises four similar sections, and each of these sections is controlled from a push-button desk fitted with an illuminated mimic diagram showing the various stations of the equipment along the line. Each section is started and controlled by a sequence interlocking system which eliminates risk of refuse being loaded on to a conveyor which is at rest. An emergency system of trip wires and buttons at strategic points in a section can be operated to stop the section. Such a stoppage is immediately shown on the diagram, and restarting can only be effected by the charge engineer after he has cleared the cause and reset the trip system.

In addition to a 410ft by 92ft garage and a 181ft by 121ft vehicle repair workshop, the plant incorporates a vehicle lubrication block and a washing stand with two two-vehicle bays. A central boiler house serving the main heating services is equipped with four horizontal super-economic boilers arranged for firing by reclaimed screened cinders or a mixture of graded coal and cinders. A large amenities block has been included for the use of personnel throughout the plant.

Technical Modernisation and New Freight Charges on British Railways

Below we print the "Summary and Conclusions" from a paper presented by Sir Reginald Wilson, Chairman of the Eastern Area Board, British Transport Commission before the British Institute of Management on Friday, November 28.

IN conclusion let me try to summarise. The facts are :

(*a*) In the vital areas and along the main arteries of this small and crowded island we cannot do without railways, or some similar technique of transport. If we did not already possess it we should have to invent it.

(*b*) Fortunately the railways already exist, though on a pattern and scale which is unnecessary, and often unsuitable, in an age when "feeding" can be done by motor instead of by horse and cart.

(*c*) Fortunately, again, much of the existing equipment is worn out or is fast wearing out. It has to be replaced. Clearly we must take the opportunity and replace to a modern pattern. At the same time some essential investment in "betterment" should be undertaken on the permanent way, or rail-road, and should be counterbalanced by a reduction in the total system.

(*d*) The public think that a vast additional investment in railways is planned. The public are wrong, but the fault lies, perhaps, with the Transport Commission, who have not made it sufficiently clear that the cash required in the coming fifteen years is largely a "replacement requirement," in the main caused by (i) under-provision for depreciation and obsolescence in the past, (ii) the heavy fall in the money-value of those provisions, such as they were. The true "growth" investment envisaged under the Modernisation Plan is small indeed, virtually nil compared with the expansion in the country's investment in roads and road vehicles.

(*e*) The cash required for the capital purposes of the railways, the day of reckoning having now come, is still only a tiny fraction of the amount spent by the country each year on consumption goods—say one seventy-fifth. I mention these things merely to dispose of current propaganda that the country cannot afford the capital now required by railways.

(*f*) The cost of re-equipping railways on twentieth-century lines will produce an excellent dividend, mainly in greatly diminished cost and better service, but also in alleviating the inevitable congestion on the roads. The technical result will be a streamlined and mechanised network of transport without compare for its high productivity.

(*g*) It is necessary, however, to ensure that this network of arterial railroads shall be properly utilised. The passenger services present no problem, except that commuters must be allowed to pay for their rides, and many of the rural trains must be replaced by buses ; the parcels and sundries traffics can be made viable without difficulty ; the basic bulk traffics can be held to rail, but may diminish in volume ; the problem therefore lies with wagon-load traffics of general merchandise, which in the past have been positively invited and encouraged to transfer to road. Of these wagon-load traffics there are considerable quantities available. On the other hand the railways have certain traffics they could do without.

(*h*) The only way to ensure that the railway has a sufficient volume of selected general merchandise in economic flows, and that thereby the technical potentials of the new era in surface transport are mobilised, is to employ the instrument of price policy (coupled with service).

(*i*) This price policy should reflect the basic considerations of railway economics, e.g. the high first cost and the low marginal costs ; the relative fixity of the investment ; the waste caused by unbalanced traffics, by thin routes, by short trains, by unfilled wagons, by slow turn round and uneconomic terminal handling ; the high cost of meeting peaks of demand and undue fluctuations of output generally ; the tendency to use it as a convenient "stand-by" ; the unreality of putting precise costs on small units of traffic, and the "jointness" of cost, and so forth. But price arrangements should take account, individually, of the realities of the competitive world as necessary, and of road costs. This is the world in which the railways now live, and they must be allowed to exercise the freedom (granted under the 1953 Act) to attack or defend, to advance upon markets or withdraw from them, by the ordinary methods of business.

(*j*) Whereas there will probably be published tariffs for parcels and small consignments, and for casual wagon-load traffic, it is likely that future policy will concentrate on offering special agreements to special customers or groups of customers covering price, volume and characteristics of their traffic—in part or in whole—for a reasonable period. We deal customer-wise rather than commodity-wise. Within reason the larger and longer the scale of the agreements the better, provided these lead to greater stability, regularity, and balance.

(*k*) A much closer relationship will gradually be worked out with customers who desire to make a constructive and long-term approach to their future transport problems.

(*l*) Subject to the limitations of circumstance, the public system will continue to do what it can to provide sufficient transport, within reason, in the peaks and in the green fields.

When I was preparing this paper I was asked whether some concrete suggestions could be made to managers, and others, about the effects on their transport policy of the shape of things to come. This, however, is hardly within my province ; nor is it a safe subject for generalisations. Each customer of the railway, and the rail-road service into which it will develop, must look at his particular circumstances and make up his own mind. There is no monopoly. He is free to do as he wishes.

From the wider and national point of view, however, we shall all help if we recognise—and keep constantly in mind—three simple facts :

(*a*) The main issues of competition are not rail versus road, but combined rail and road versus road throughout ; and not between public transport enterprise and private transport enterprise, but between basic providers and the selective or ancillary operator ; and between short-term and long-term possibilities.

(*b*) The success of railways will be an argument in favour, not of nationalisation, but of rationalisation on a large scale combined with first-class service.

(*c*) The more the railways are used, properly, the cheaper they will be.

There is no question of divine right for railways. They are only part of a larger whole, but we may as well make them as efficient as we can, and use them in such fashion as will exploit their potential for high productivity in bulk-arterial transport.

SHORTER REPORTS

Subscriber Trunk Dialling in Great Britain

THE first subscriber trunk dialling service in Great Britain was inaugurated by Her Majesty the Queen on December 5 at the Bristol Central Telephone Exchange. With this service 18,000 subscribers connected to the Bristol telephone exchange are able to make trunk calls to about half the subscribers in this country without the help of operators and using, instead, the Group Routing and Charging Equipment known as "GRACE."* In response to a Bristol subscriber's dialling, "GRACE" automatically sets up trunk calls by noting the number required, selecting the correct route and charging for the call at the appropriate rate.

The equipment is constructed on a unit principle, so that its size can be readily suited to the needs of a particular exchange and can easily be enlarged to meet growth in telephone traffic. The Bristol installation is capable of completing over 6000 calls per hour. To obtain connection to "GRACE," and to present the required exchange and number to the equipment in a suitable form, the subscriber dials the national number of the subscriber he requires. The national number consists of a series of figures and letters to identify the required exchange, followed by the called subscriber's local number; all national numbers start with "O" and dialling "O" connects the call to "GRACE."

Call Charger.—Initial connection is made to a register access relay set or call charger. The call charger remains associated with the call throughout its duration, its main function being to start charging at the appropriate rate when the call is answered and to continue charging until the calling subscriber hangs up. For setting up the call and selecting the correct charging rate, two further items of equipment, a register and translator, are called into use.

Registers, which are used only during the setting-up of a call, are provided in a common pool which can handle sixty-six calls simultaneously. A call charger taken into use by a call associates itself immediately with any available free register. The registers are of electronic design, based on the use of cold-cathode tubes interconnected by miniature selenium rectifier gates. The number dialled by the subscriber is received by the register, counted and coded electronically and stored on cold-cathode tubes in "2-out-of-5" code. A total of forty-five tubes per register is provided for this purpose, giving a capacity for nine digits.

Translator.—The first one, two or three digits received by the register identify the charging group of the wanted exchange. It is the function of the translator to inspect these digits and deduce from them the route and charge rate for the call. The translator is in effect the memory of the system, storing a permanent record of the route and charge rate for all calls that can be made by Bristol subscribers. The translator is also of electronic design and can deal with a register in a few milliseconds. This high speed of operation permits it to control up to forty registers, to each of which it is connected sequentially by electronic gates once in two-thirds of a second. Each time it is connected to a register it decides what action if any is required and sets the register to perform this operation. While the translator is dealing with its other registers, the register carries out the specified operation and, when this is completed, receives a further instruction on its next connection to the translator. This master control arrangement permits a relatively simple design of register, since it is called upon in the main to carry out only similar and simple operations.

Instructions to Register.—The first instruction given to the register is a signal representing the charge rate for the call. This is passed by the register to the call charger, where it sets an electromechanical switch to select the appropriate metering rate ready to start charging when the call is answered. Subsequent instructions cause the register to send suitable signals to the automatic switches in the local and distant exchanges to route the call to the required exchange. These signals are followed by the digits of the called subscriber's number, which have been stored in register and select the required line. When the connection is complete, the register releases from the call charger and is free to set up further calls. When the call is answered, the call charger operates the calling subscriber's meter once and then periodically throughout the call at intervals of time, depending on the distance.

Metering.—The meter on which the call charge is recorded is the one previously used only for recording local call charges. It is a reliable mechanism of the Veeder type and each line in the exchange has its own meter. If, however, a subscriber must know the cost of a dialled call at the time it is made to charge it to the user (e.g. in a hotel), a meter can be rented and installed at his premises to work in step with his meter at the exchange. Operation of this meter is controlled by an equipment in the exchange which responds to the charge units received by the subscriber's exchange meter and connects a pulse of 50 c/s alternating current to the line. This signal passes over the two wires of the line in parallel, via the meter at the subscriber's premises to an earth return. By applying the signal in this balanced manner no interference to the subscriber's conversation is caused.

The meter has a sensitive moving-iron movement tuned to 50 c/s to prevent misoperation by ringing current or dialling surges. It is equipped with three hands, which move over a graduated scale, taking one step for each pulse of current received. Two of these hands indicate the total number of 2d. charge units used while the third indicates the number of units used on individual calls and can be set to zero after each call.

"GRACE" was designed and developed under the long-standing procedure for joint development between the Post Office and the leading manufacturers of telephone equipment in the United Kingdom—the Automatic Telephone and Electric Company, Ltd., The General Electric Company, Ltd., Ericsson Telephones, Ltd., Siemens Edison Swan, Ltd., and Standard Telephones and Cables, Ltd., The main contractor at Bristol was the Automatic Telephone and Electric Company, Ltd., but The General Electric Company, Ltd., supplied and installed the registers and translators for "GRACE." Subscribers' private meters have been developed in co-operation with Smith's Industrial Instruments, Ltd., and Ferranti, Ltd.

It is planned to extend the subscriber trunk dialling to forty-six other towns in Great Britain by 1960.

* A description of the "GRACE" equipment appeared in THE ENGINEER, November 22, 1957, page 278.

Fleet Replenishment Ship

THE completion of another fast replenishment vessel—the R.F.A. "Reliant—which sailed last month for the Far East after conversion, indicates the importance now attached to the ability of the Fleet to operate over longer periods independently of organised shore bases. Apart from tugs and salvage vessels, the Royal Fleet Auxiliary service comprises tankers and shore issuing vessels for the replenishment of warships at sea or in harbour and is manned by Merchant Navy officers and seamen who, in the main, are engaged on normal Board of Trade articles. These ships fly the Blue Ensign, but are in a real sense part of the strength of the Fleet. Despite the limited amount of money allowed for new construction, the Admiralty has recently managed to build three fine 18-knot replenishment ships—vessels of 17,700 deadweight tons, with a fuel cargo carrying capacity of 15,000 tons. They are capable of discharging oil fuel to ships on either beam or astern while steaming at high speed, and are fitted with modern handling gear for transferring food, stores, ammunition, oil, &c., by jacketing and derricks. Three more somewhat smaller and slower vessels have been or are being converted for use as fast supply ships. The R.F.A. "Retainer" was the first of the latter to join the Fleet, followed last November by the "Reliant."

The "Reliant," formerly a carrier of grain from the Gulf of Mexico to the United Kingdom, has now sailed to take up her role as the Royal Navy's first air-stores issuing ship, capable of replenishing aircraft carriers at sea. She can steam for fifty days at 16 knots and carries over 30,000 different kinds of aircraft spares and general naval stores, ranging from ¼in diameter washers to flight deck tractors weighing 2 tons. Eventually, the vessel will carry about 40,000 different patterns of stores and two civilian officers will be permanently at work on board her, maintaining store accounts and stock levels. Her six holds are fitted to make her the most modern travelling store room afloat. Any one of the thousands of different store items can be located by the civilian store officer and taken up on deck within a few minutes. The latest automatic tensioning winch on deck makes it practicable for the "Reliant" to transfer stores to aircraft carriers under almost any conditions of weather. She carries a complement of 110 officers and men and is fully air-conditioned for service in the tropics.

Tests on Light Alloy Stiffener Sections

ON November 28, Mr. M. N. Parker and Mr. K. V. Taylor jointly presented a paper entitled "Tests on Light Alloy Stiffener Sections" before the North East Coast Institution of Engineers and Shipbuilders.

The range of light alloy sections now available for marine purposes has been developed during the past ten years and to expedite this development in the initial stages, the British Shipbuilding Research Association undertook the testing of a series of stiffener sections consisting of 9in channels and bulb angles, each in a range of web thicknesses. Bars were extruded from both the shipbuilding alloys N.6 and H.30 and two kinds of test were carried out to determine their suitability for use in shipbuilding; structural tests at Glengarnock for which the sections were connected to plating with ¾in hot-driven aluminium-alloy rivets and provided with various forms of end connection: and shipyard forming tests, at Alexander Stephen and Sons, Ltd., to determine the workability of the material.

The Glengarnock test specimens were of 16ft span and loaded through the plating. The results show that within the elastic range the deflections and stresses were for practical purposes proportional to the inertias and section moduli respectively. In tests to destruction carried out on the bracketed specimens with load applied to the clear side of the plating so that the brackets were in compression, failures occurred in the stiffeners of N.6 alloy with the thinnest webs. In all the specimens in which light alloy angles were used to connect the brackets to the end structures of the machine, these were the first members to fail. When these were replaced by steel connecting bars of the same scantlings, failure occurred at a higher load as the result of buckling of the brackets.

The shipyard tests showed that all the sections were suitable for punching, joggling and bevelling; the N.E.6 and H.E.30 bulb angles could be bent cold to a radius of about 6ft in a bar-bending machine, and the N.E.6 angle could be bent hot on the bending slabs to the same radius; but cold bending of the H.E.30 material on the slabs was possible only when the curvature required was small.

Water-Cooled Power Cable

DURING a recent press visit to the Woolwich and Blackheath works of Siemens Edison Swan, Ltd., the visitors were able to see some of the recent developments of the company's products. These included an internally water-cooled power cable, stated to be capable of carrying over twice the current permissible in an ordinary solid copper conductor. A section of the cable may be seen in Fig. 2. It has a copper section of 0·5 square inch, the conductors being supported on a central, closely-wound copper helix (here pulled out for the sake of showing the construction). The conductors are surrounded by a plastics sheath backed by heavy polythene insulation which, in turn, is protected by glass fibre. Designed for an operating voltage of 8kV to 10kV, the cable can carry 850A without forced cooling but over 1600A if cooling water is circulated. Pressure tests have shown the cable to withstand 200 lb per square inch for a short time and 70 lb per square inch for protracted periods. In a demonstration which was given, a 100 yard length of cable carried the full rated current with a flow of coolant of 1 to 1½ gallons per minute, the water rising in temperature from 15 deg. to 40 deg. Cent.

The water-cooled cable was developed for applications where space is at a premium, such as equipment for thermonuclear fusion work and nuclear research. Fig. 1 shows its application to the 300 MeV synchrotron for Glasgow University, the rating of which is being increased to 450 MeV. It is considered that there may be scope in power generation where capital savings might be achieved by reducing the size of plant for a given output.

In a newly-assembled museum, the company is endeavouring to collect as many as possible of the surviving examples of early submarine cables, telegraph and telephone equipment, and incandescent lamps, as well as documents relating to the founders of the parent enterprises.

In the development of electronic telephone exchanges, work is continuing along two main lines, involving time-division and space-division switching, methods by which the number of available speech channels can be substantially increased. Substantial savings in the size of the equipment and power consumption were made possible by miniaturisation, printed circuits, and the use of transistors in place of valves. One development which, it is stated, may have an important bearing on future trends is that of a wire-wound, helical, low-loss waveguide. Such a waveguide, measuring about 2in in diameter, is stated to be capable of transmitting simultaneously on twenty television, sixty visiphone, 10,000 telephone, and 20,000 data transmission channels.

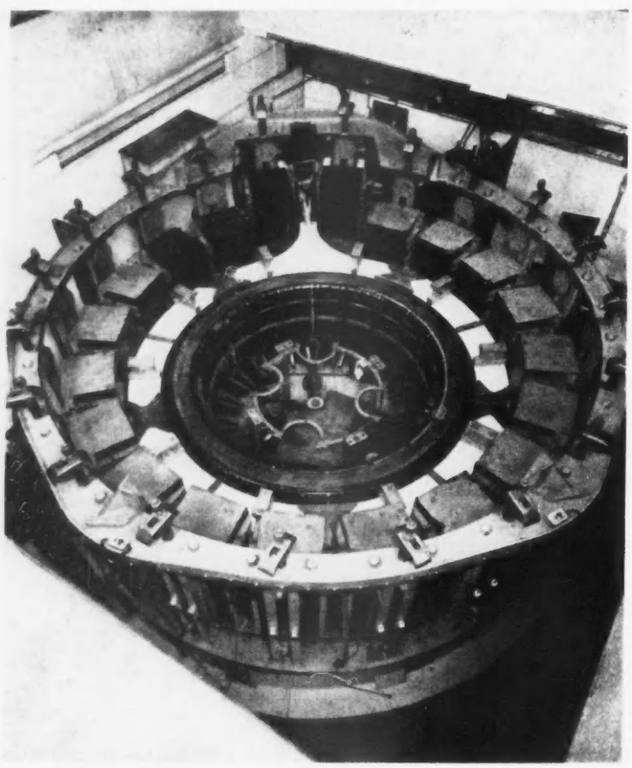


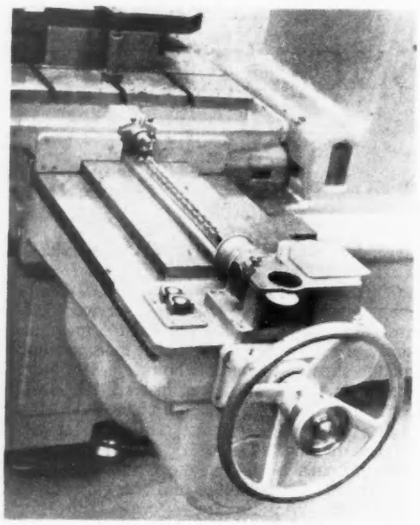
Fig. 1—Magnet ring for 450 MeV synchrotron of Glasgow University. The water-cooled coil is under the white cover plate; the terminals are visible at the top

Fig. 2—Water-cooled cable : the central spiral is pulled out to show the construction, but actually forms a closed helix

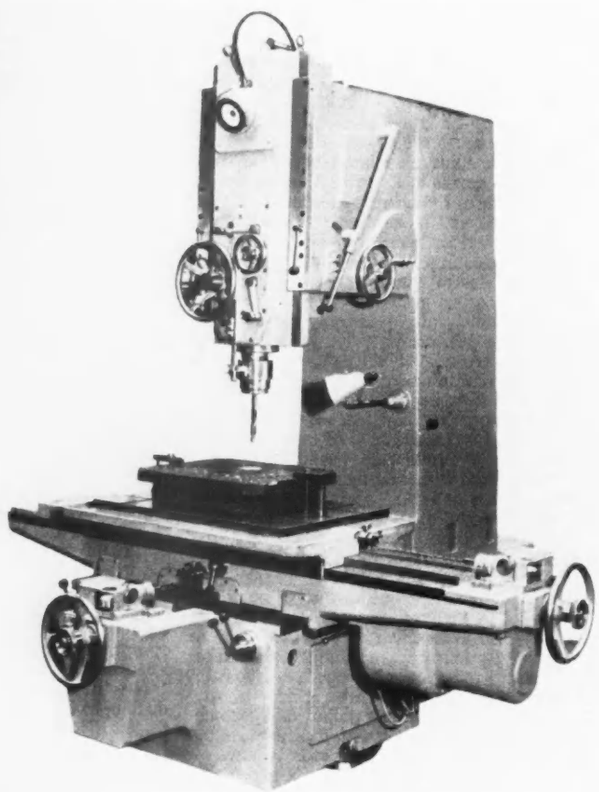
Jig Boring Machine

FOLLOWING three years of successful operation of prototype machines in the makers' works, Stanley Howard, Ltd., 73, Devon Street, Birmingham, 7, has now placed upon the market the "Master Bar" jig boring machine we illustrate on this page. The machine has a 42in by 25in table with a longitudinal travel of 30in and a transverse travel of 18in. Its boring head slide has a vertical movement of 16in on the column and in it the spindle has a travel of 9in ; the centre line of the spindle is 24in from the face of the column. The boring head slide is so designed that the spindle axis is in line with the double vee slideways of the column to eliminate overhang and increase rigidity when the machine is in operation. Vertical movements of the head are electrically driven through push button control and, as with the table slides, limit switches prevent over-travel. A vernier scale on the face of the head can be used for measurement purposes when adjusting the slide, and a fixed dial gauge working in conjunction with slip gauges can be used for spindle settings.

The longitudinal and cross traverse movements of the table are effected by leadscrews driven by motors under the control of directional push buttons. The automatic measuring system used for work positioning is based upon "master bars" beneath each slide. These master bars have precision grooves machined across their



Longitudinal slide of jig boring machine showing master bar with micrometer and dial gauge setting equipment



"Master Bar" jig boring machine

top faces at increments of 1in and a slip roller gauge provided for each bar is a push fit in the grooves. The means of table setting can be followed by reference to our second illustration. With a roller in an appropriate groove in its master bar the decimal setting of a length is effected by adjusting a fixed micrometer drum at the end of the bar.

A latch is set on each moving slide above the master bar, and when the table is being traversed to the predetermined position by depression of its directional button this latch comes into contact with the roller in the groove. The latch, through the roller, slides the master bar along a short distance until a micro-switch in the leadscrew assembly is tripped. This switch stops the leadscrew motor and, at the end of a very short movement due to the inertia of the table, a second micro-switch is actuated to apply a brake. At this stage of automatic setting the table is positioned to within 0·010in to 0·015in of the required point. Final setting is accomplished through the leadscrew handwheel with reference to a 0·0001in dial gauge.

Spindle drive is from a Sturm hydraulic motor set enclosed in the base and column of the machine, and the drive is transmitted through a two-speed gearbox. With this arrangement there are provided two steplessly variable ranges of spindle speeds from 40 to 1800 r.p.m. and 40 to 450 r.p.m. Four spindle feeds provide 0·001in., 0·002in, 0·004in and 0·008in travel per spindle revolution.

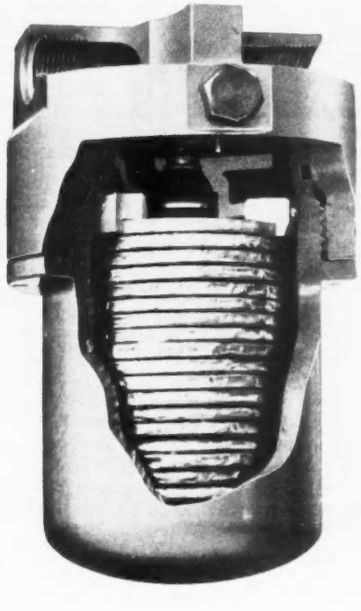
The makers have introduced an interesting method of location of the taper tool holder adaptor in the spindle nose of this machine. The adaptor has a locating ring with three locating pegs equally spaced on a pitch circle diameter, one peg being larger than the others. Three complementary slots are machined round the spindle end and final locking of the adaptor is by a nose locking ring. With this arrangement the adaptor is always replaced in the same position in the spindle, and this ensures consistent accuracy in positioning.

Aircraft Quality Filters

SOME details have been received from Palmer Aero Products, Ltd., of the filters of their manufacture to the designs of Parmatic Engineering, Ltd., of Canada. Filters are available with numerous different media—sintered wire, sintered powder, felt, or paper—and the company offers a consultancy service to match particular requirements : if necessary, filters beyond the normal performance ranges of —55 deg. to 200 deg. Cent. and 6000 lb per square inch, can be made.

We illustrate a typical Palmer-Parmatic filter, the high-pressure model D.1021, equivalent to the model 1140 used in the flying control system of the Avro "C.F.-100" : it filters down to 5 microns, with a pressure drop of 15 lb per square inch at 7 gallons per minute. In the central passage immediately above the element can be seen the cut-off valve, which, closing when the bowl is removed and opening when it is replaced, avoids any spillage of liquid when dismantling. The hexagon head on the front of the filter in our illustration is loosened before the bowl is unscrewed, allowing the cut-off valve to rotate as the bowl is turned and open an air bleed : thus the bowl does not have to be forced off against atmospheric pressure. The bleed stays open until the bowl is tightened up again, allowing air in the top of the filter to be expelled. The by-pass relief valve, which opens at 80 – 20 lb per square inch, is located at the top of the filter, and flow through it does not entrain the accumulated foreign matter : this valve has a knife-edge seal in which dirt cannot be trapped. The element shown is of sintered bronze and cleanable, but throw-away elements can be used. The casing is of aluminium alloy, and has been fatigue tested over 100,000 cycles, 0 lb to 3000 lb per square inch.

On low-pressure filters a bayonet fixing for the bowl is used : actuation of the locking lever also opens the air bleed.

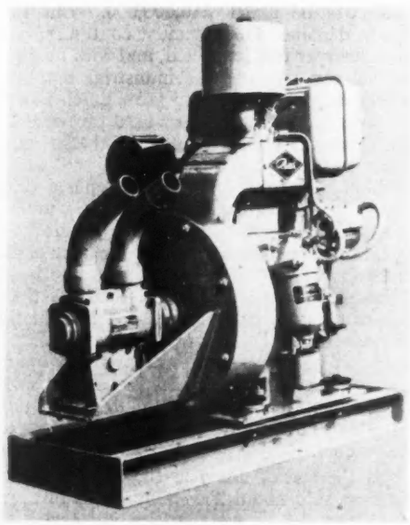


Hydraulic fluid filter with cleanable sintered bronze element straining to 5 microns

Portable Pump Set

WE illustrate a pumping set now being made by Goodyear Pumps, Ltd., Camborne, Cornwall, in which there is combined one of the firm's positive displacement high-speed pumps, and a high-speed Petter air-cooled diesel engine.

This set is designed to deliver 30 gallons per minute at 200ft head of water and is capable of suctions of up to 27½in of mercury, whilst the pump is self-priming and can run for long periods "on snore."



Goodyear positive displacement pumping set with a Petter 5 b.h.p. air-cooled diesel engine. This pump delivers 30 g.p.m. against a head of 200ft

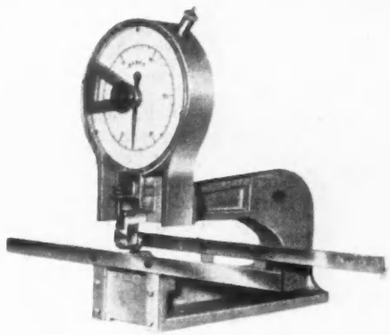
The 348 c.c. engine, a "P.C.1." such as was described on page 911, June 14, 1957, develops 5 b.h.p. at 3000 r.p.m. and the pump is mounted to its cast bell housing by a carrier comprising an annular ring and a platform. The platform with its supports is welded to the annular ring and the pump is mounted directly on to the platform. A wire mesh guard welded across the centre of the ring protects the flywheel fins, and allows ample air intake for cooling.

Drive is transmitted to the pump through a short shaft bolted to the engine flywheel, a high-torsional Spencer Moulton "Jubo" flexible coupling being incorporated in the shaft assembly to ensure smooth power transmission and compensate for any displacement or misalignment.

The engine is mounted on two lengths of machined ½in plate which in turn are mounted on a channel sub-base. Between the sub-base and the plates are four Silentbloc "Frustacon" anti-vibration rubber mountings. This type of mounting enables the unit to be rested on any reasonably firm ground whilst in operation, and the total weight of the unit including the mounting is 354 lb.

Sheet Thickness Calibrating Machine

A SHEET thickness calibrator made by F. J. Edwards, Ltd., 359–361, Euston Road, London, N.W.1, and illustrated below, is intended for the sorting of sheets up to ½in thick into respective group thicknesses. Although specially intended for use with tinplate light sheet metal, the instrument is also suitable for use with steel, brass, aluminium, plastics, cardboard, paper, leather, &c., in sheet form. With this machine the sheets to be sorted are pulled through the hardened rollers by hand, and their thickness is registered on the dial above. It is stated that up to 1500 sheets per hour can be handled in this way.



Machine for sorting sheets up to ½in thick into thickness ranges

The standard instrument is fitted with a plain dial and two adjustable gauges for sorting sheets into light, medium, and heavy categories, but models with calibrated dials, and suitable for handling sheets thicker than ½in, can be supplied to special order. The distance from the thicknessing rollers to back of gap in the frame of the machine is 12½in.

Symposium on Shaft Sinking and Tunnelling

THE Institution of Mining Engineers has organised a symposium on shaft sinking and tunnelling to be held at Olympia, in London, from July 15 to 17, 1959, coinciding with the exhibition of mining machinery. The council of the Institution points out that with the many developments in this field in recent years, the time is opportune for such a symposium.

A preliminary indication has been given by the Institution of the papers to be presented at the symposium, which indicates that it will be international in character. Nineteen contributions are listed, from eleven countries. Shaft sinking problems will be expounded in papers from nine countries, including two papers from South Africa and one from Germany, and also a paper on the freezing method from the U.S.S.R. The tunnelling papers will include a review of tunnelling on the Snowy Mountains hydro-electric development in Australia, and papers on tunnelling in the U.S.A., Canada, Germany and France. Five papers are to be presented by British authors. They will deal with shaft sinking and tunnelling for the National Coal Board, and will include also a review of the cementation process.

Industrial and Labour Notes

Thames-side Industry

The Ministry of Housing and Local Government announced last week that the Minister, Mr. Henry Brooke, had approved, with modifications, Part B of the Kent Development Plan, covering the north-eastern area of the county. Because of the heavy concentration of industry already in the Thames-side Town Map area, particularly to the north of the A2 trunk road, he has reduced the allocation of further land for industry in the area. Requirements for the essential re-siting of industry already in the area, and for the known expansion of a few well-established industries necessarily tied to the district, have been taken into account. Applications to develop land which industrial concerns are holding in reserve for possible expansion will be considered on their merits in the light of the general industrial policy for the Town Map area. This area comprises the boroughs of Bexley, Dartford, Erith and Gravesend, the urban districts of Crayford and Swanscombe, part of the urban district of Northfleet and part of the rural districts of Dartford and Strood.

As a housing safeguard, within that part of the Thames-side Town Map area inside the Metropolitan Police district, a planning permission will not normally be given to change the use of residential property, still capable of being used for housing.

The line for the Swanley by-pass shown in the plan had been deleted, but the Minister emphasised that he had done this in the knowledge that an alternative route for this trunk road was under consideration by the Minister of Transport.

Part A of the Kent Development Plan, relating to the rest of the county, was approved last January.

Census of Production

After consultation with the Census of Production Advisory Committee the Board of Trade has issued a preliminary notice dealing with the census of production for 1959, to be taken in 1960. This will be the first of a series of simple annual censuses for the years between the detailed census for 1958 and the next detailed census. Two important changes concerning the information required, and the unit to which the returns will relate, will simplify the 1959 census still further. The industries covered are contained in Orders II–XVIII of the new edition of the Standard Industrial Classification, and consist of mining and quarrying, manufacturing, construction, and the gas, electricity and water supply industries. With the exception of those contributing to the Board of Trade's quarterly inquiries into stocks and capital expenditure, returns will be required from all firms in this field employing twenty-five or more persons.

The information required will be less than in any previous census and will cover only the total value of goods sold and work done, stocks and capital expenditure. The capital expenditure section will contain questions relating to the cost of land and existing buildings acquired, and the proceeds of land and buildings disposed of, in the year, and new building work. Particulars of employment, wages and salaries, materials and fuel purchased, work given out and payments for transport will not be obtained in this census. Arrangements are being made, the Board states, for the Ministry of Labour and National Service to collect information about salaries, to replace that hitherto obtained in the census.

In the great majority of cases, the return for 1959 will cover the entire business of the undertaking, including any activities which are ancillary to the main business, even when they are carried on by a separate company, but where, however, a holding company or group includes units engaged in diverse activities for which separate sets of accounts are kept, separate returns will be required. The Board of Trade says it will be glad to discuss the application of these principles with any firm wishing to settle the form of its return beforehand. Inquiries should be made to the Census Office, Lime Grove, Eastcote, Ruislip, Middlesex.

Coal Production Plans

The National Coal Board discussed with representatives of the National Union of Mineworkers in London last Wednesday its plan to reduce production in 1959. In a statement issued by the Board it is pointed out that the measures taken earlier this year to meet the fall in demand achieved their objectives. Output has been cut by 9,000,000 tons and the labour force by 20,000 men. Costs and prices have been been kept steady, and redundancy has been avoided. On a turnover of nearly £1000 million, the loss for 1958 will be under £10,000,000. But the fall in demand, the statement continues, has been sharper than expected, and with no sign of an early revival in industrial activity, stocks cannot continue to grow much more. To meet this situation the Board proposes to cut open-cast output by 3,000,000 tons, and deep mined output by about the same amount. The reduction in deep-mined output will be brought about by the planned closure in 1959 of thirty-six pits (in addition to the dozen or so due to close for exhaustion). Between 12,000 and 13,000 men work in these pits, but it is thought that less than one-third may have to leave the industry permanently. The Board proposes, with the Minister of Power's agreement, to cut open-cast production by 20 to 25 per cent, in spite of the fact that opencast mining is highly profitable and yields a great proportion of large coal.

By the end of this year the Board expects to have sold about 205 million tons of coal, whilst output is expected to come out at about 215 million tons. Unsold stocks at the end of the year are likely to total 19,000,000 tons. Even with the proposed reduced production next year, there may have to be some stocking, perhaps of 3,000,000 tons. At each of the thirty-six pits which are to be closed, there will be full consultation with the unions, and those men for whom no work can eventually be found will qualify for benefit under the compensation for redundancy agreement.

British Metal Sinterings Association

The formation of the British Metal Sinterings Association was announced at a press conference held at the Federation of British Industries' London offices on December 4. Founder members of the Association are : Bound Brook Bearings, Ltd., The Manganese Bronze and Brass Company, Ltd., Metal and Plastic Components, Ltd., The Morgan Crucible Company, Ltd., John Rigby and Sons, Ltd., Sintered Metal Components (Chard), Ltd., and Sintered Products, Ltd. The secretaries are Peat, Marwick, Mitchell and Co., Beaufort House, Newhall Street, Birmingham, 3. Mr. E. Robson, managing director of The Manganese Bronze and Brass Company, Ltd., is the association's first chairman.

The aim of the association is to place at the service of industry the combined experience of its members, and inquiries received by the secretaries will be passed on to all the member firms, thus ensuring that the firm with the most experience in a particular field will have the opportunity of putting forward the best solution to a problem in that field. An illustrated brochure has been produced containing sections dealing with the metal sintering process, the advantages of metal sintering, tolerances, design considerations, toolmaking, lubrication and protection, and some typical physical properties. Copies may be obtained from the Association secretaries.

The Problem of Wages

The Henry Spurrier Memorial Lecture to the Institute of Transport entitled " The Problem of Wages," was delivered last Monday by Mr. E. R. L. Fitzpayne, M.I.Mech.E., M.I.E.E. In it Mr. Fitzpayne referred to some wage settlements made in the current year. The essence of Government policy during 1958, he said, had been to keep wage increases in step with production, but productivity must be viewed from a national basis, and the decision of the Electricity Authorities to grant an increase of 8s. 3d. per week because of increased productivity in their industry was questionable and undoubtedly had an unfortunate effect on other wage negotiations. Government warnings on the danger of wage increases did not deter the unions from lodging their claims, Mr. Fitzpayne continued, and one of the first to be submitted was with the London Transport Executive for a wage increase of 25s. per week. There was no justification, on price movements during the previous twelve months, for such a claim, he stated. Meanwhile, the majority of the railway wages tribunal decided that it could not recommend an increase this year for railway workers, and it did appear that a major industrial strike was imminent.

Early in May the union rejected London Transport's offer to grant 8s. 6d. per week to the central busmen and to review the wages of the country busmen in the autumn, and a London bus strike took place. In the interval a railway settlement of a 3½ per cent increase with a promised review in the autumn had been effected, and prior to the strike London Transport had promised to bring forward its review of the wages of the country busmen from the autumn to the summer, but this, said Mr. Fitzpayne, was of no avail. Whilst the strike had a disastrous effect on London Transport, it probably assisted in slowing down the wage inflation in other industries.

It was too early to express an opinion on the effectiveness of Government policy in 1958, Mr. Fitzpayne said, but the evidence did indicate that wage increases had been at such a level as not seriously to affect the price level as indicated by the cost-of-living index.

Stornorrfors Power Station

After a construction period of five years, the first set at Stornorrfors Power Station, on the Ume river in Northern Sweden, came into service on October 1. This will be followed by two further sets, in January and May of next year, bringing the installed capacity to 375MW, and provision has been made for a fourth set of the same size to be installed when additional catchment regulations permit it. Besides being the largest hydro-electric station in Sweden the plant, which is entirely underground, is of interest because of the extensive excavations carried out, in particular for the machine hall and the tailrace. The cost of £36 per installed kilowatt is stated to be about one-third of the cost for similar installations elsewhere in Western Europe.

ON October 1, the first set of Stornorrfors power station came into service. The station, construction of which began in 1953, is Sweden's largest, its three Francis sets being designed for a nominal output of 375MW. The second generator set will begin to operate next January, and the third in May; there is room, however, for installing a fourth set, which would bring the station up to 500MW. By comparison, Harssprånget, the second largest hydro-electric station in the country, completed in 1951, has three sets with an installed capacity of 350MW.

Stornorrfors is utilising the last, about 15km long, section of rapids of the river Ume in Northern Sweden, not far from where this river reaches the Gulf of Bothnia. These falls were already partially exploited by the stations Norrfors, Klabböle and Baggböle, of which the largest, Norrfors, dated from 1928 and had an installed capacity of 26MW. These three stations were discontinued when the new plant was put into operation.

Fig. 1—Catchment area of Stornorrfors includes the rivers Ume Alv and Vindelälven with their tributaries, covering an area of 26,500 square kilometres. Storage capacity of 1390 million cubic metres may later be increased to 4200 million cubic metres

Hydrology

Water at Stornorrfors is derived from a catchment area of 26,500 square kilometres (Fig. 1). This includes the systems of the Ume Alv with Lake Storuman, and of the Vindelälven, with power stations at Harrsele, Lycksele, Sorsele and Tärna. Storuman, the largest of the lakes, is situated some 200km above Stornorrfors. It has a storage capacity of 1390 million cubic metres, and its regulation was practically completed at the time the power station was commissioned. Additional regulations are contemplated above this lake and on the Juktån river which will increase the total storage to 4200 million cubic metres. Future regulations of the tributary Vindelälven have also been considered.

Flow conditions at Stornorrfors are as follows, figures in parentheses being for a storage of 1390 million cubic metres. Exceptional high water flow is 2860 cumecs (2450 cumecs), normal high water flow 1800 (1450), and mean water flow 442 (442) cumecs, while in a normal winter, the average is 236 (295) cumecs, and in a dry winter, 155 (185) cumecs.

As far as flow is concerned, the Ume river is Sweden's second largest river, being surpassed only by the Götaälven in south-west Sweden, with a mean flow of 575 cumecs.

Dams

Ten earlier dams, designed to protect some of the low-lying sections of the storage area from floods during the spring, had to be rebuilt to conform to the increase in average level. Some 3km above the station, the falls are impounded by three dams (Fig. 2). One comprises a 57m wide spillway (Fig. 3) with two 21m wide segment gates and one 15m wide vertical sector gate to accommodate logging. In addition, there is a 21m wide emergency opening which is sealed by a concrete wall which can be blasted open during a severe flood. At all the openings the depth of water over the sill is 9·4m while the normal discharge capacity is $2 \times 1200 + 1 \times 800 = 3200$ cumecs. This can be increased to 4200 cumecs by utilising the emergency opening as well.

On the left, a 100m long by 19m high buttress dam adjoins the spillway followed by connecting dams on either side. These are rockfill structures totalling 525m in length and measuring 5m in width at the crest. Their maximum height is 13m and they contain 45,000 cubic metres of fill. At Tvärön, there is a 230m long, 50,000 cubic metres rockfill dam, 18m high and 5m wide at the crest, while at Tvärän, a 25m high dam of 5m width at the crest extends over 220m and has a volume of 170,000 cubic metres.

In order to prevent the old river bed from drying up completely at certain times of the year, it is planned to construct a number of small dams so as always to retain some water.

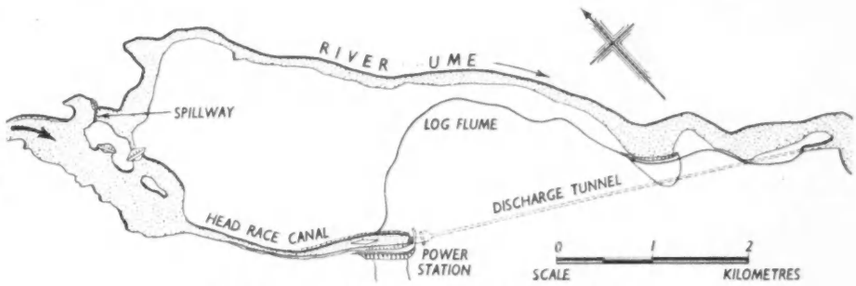


Fig. 2—General layout of Stornorrfors power station

Fig. 3—Stornorrfors power station spillways with 21m Taintor gates. The buttress dam was carried out with sliding shuttering

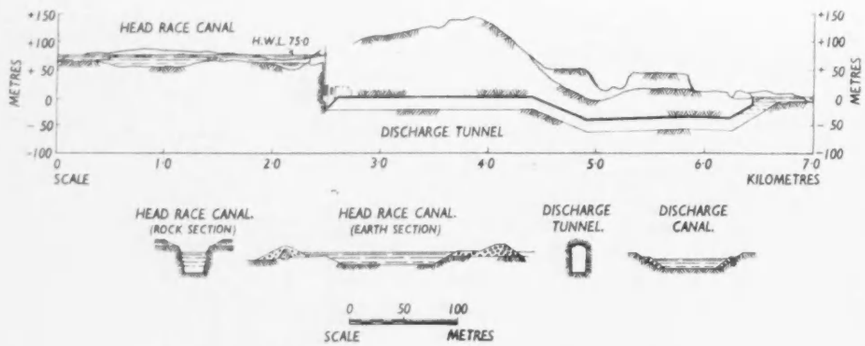


Fig. 4—Longitudinal section through Stornorrfors power station

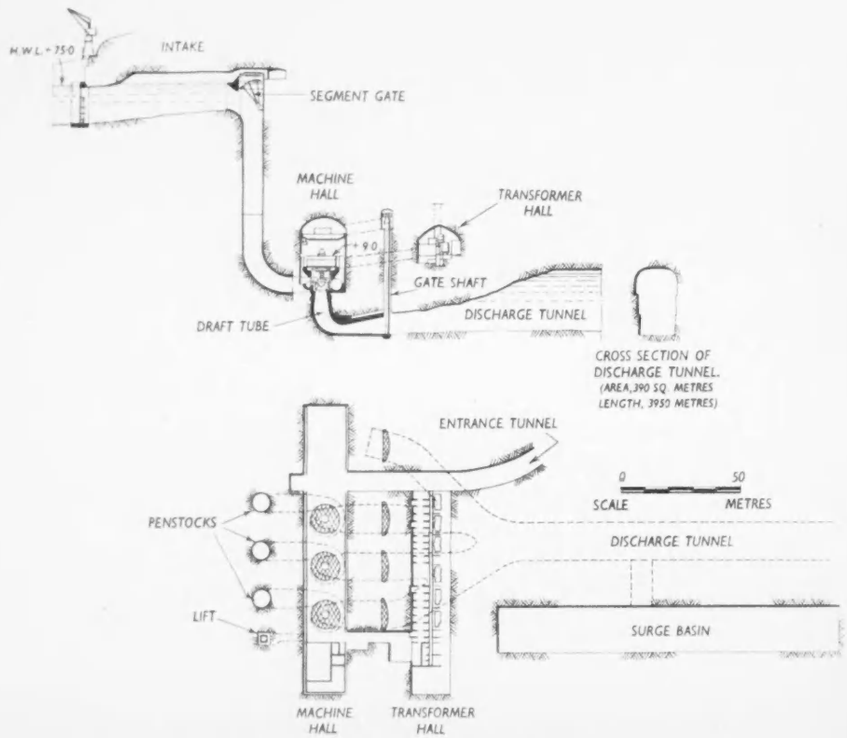


Fig. 5—Vertical and horizontal sections of the power station

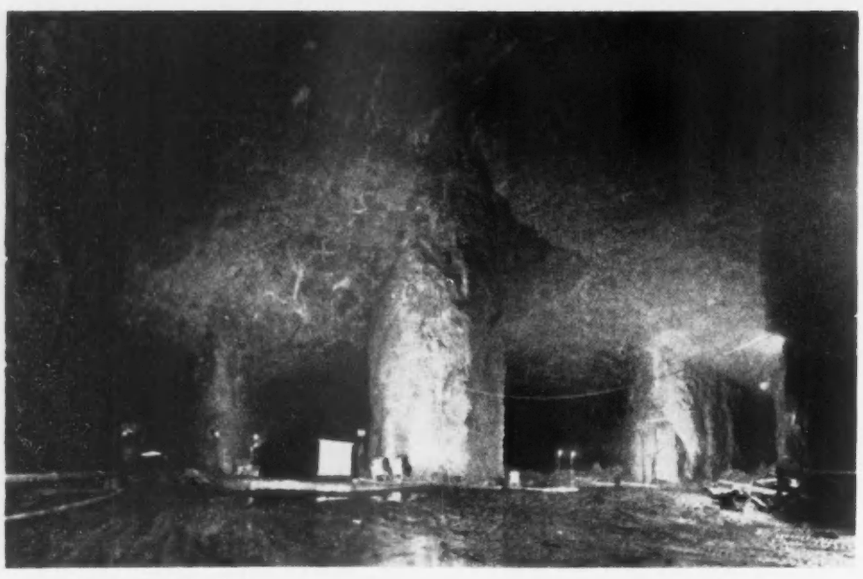


Fig. 6—The four draught tubes run from the discharge tunnel. Note the smooth rock faces

Power Station

A longitudinal section of the power station is illustrated in Fig. 4. The head race has a total length of 2400m, and its construction involved the excavation of a total of 1,300,000 cubic metres of earth at the ends and 600,000 cubic metres of rock in the middle. The large entrance section of 1350 square metres is designed to limit the speed of flow and permit an early freezing over. The rocky part has a section of 410 square metres. A concrete arch bridge of 49m span carries the highway across the canal, some 500m upstream from the intakes in the beginning of a 5·7km long log flume which empties into the discharge canal; this runs about 12 cubic metres per second of water and has a capacity of 25,000 logs per hour.

Three separate channels, under an overhang of granite rock, admit the water to the intakes which are equipped with quick-acting Taintor gates. The three vertical penstocks are 8m in diameter and have a steel lining backed by grouting.

In common with a large proportion of Swedish hydro power stations, Stornorrfors is entirely excavated from the rock. It is believed to constitute the largest excavation in the world other than certain underground transport systems. A sectional elevation and plan may be seen in our illustration (Fig. 5) which shows the underground intakes, penstocks, machine hall, draught tubes and discharge tunnel, transformer hall, gate shafts, and adits. One of the principal advantages of underground construction is that work can be continued right through the six winter months when temperatures for a prolonged period may be down to —20 deg. Cent. (—4 deg. Fah.) or even lower.

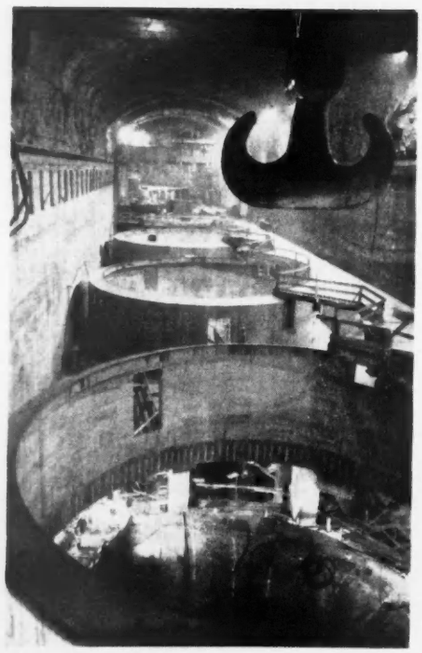


Fig. 7—The machine hall under construction, showing three turbine pits in the foreground. One of the generators being assembled at the back was later placed in position by the two travelling cranes

Large underground power stations were rendered economically attractive by the development of the so-called "Swedish" tunnelling method by the firms Atlas Copco AB and Sandvikens Jernverks AB, in co-operation with their customers. In the excellent granite rock at Stornorrfors, a remarkable performance was achieved, both with regard to the size of the main cavities and the speed of their construction. Originally, the tailrace had been projected as two separate tunnels, but eventually it was decided that it would be cheaper to construct a single large tunnel. With a length of 3950m, a height of 26·5m and a cross section throughout of 390 square metres, this tunnel required the excavation of 1,540,000 cubic metres of rock

Fig. 8—Assembly of the turbine runner. The hub is being lowered on to the blade assembly prior to welding

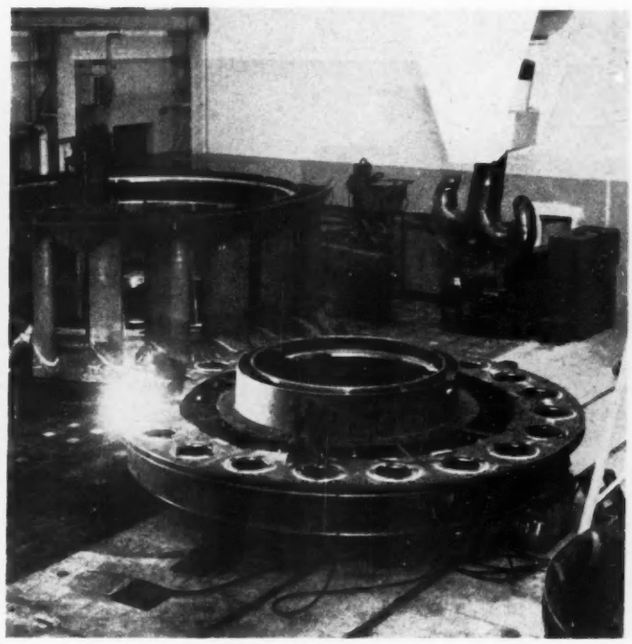


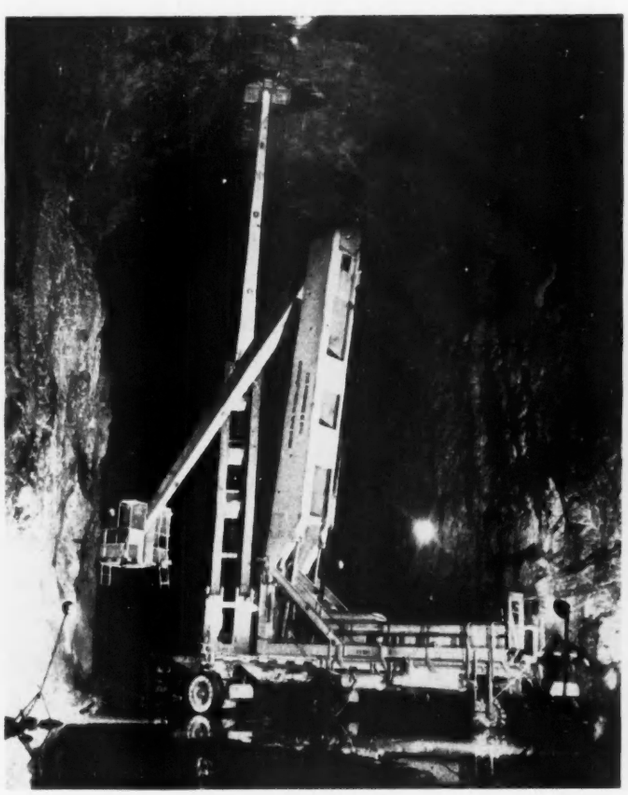
Fig. 9—Fabrication of a head cover for one of the Francis turbines. On the left may be seen a stayring

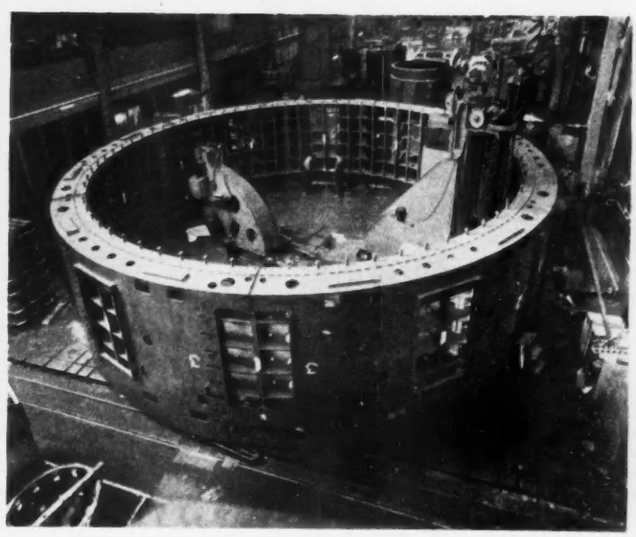
(Fig. 6). A surge basin, parallel with and connected to the discharge tunnel, has been constructed immediately downstream of the draught tubes. On leaving the tunnel, the water is returned to the river by means of a 500m long canal with a width at the bottom of 44m and an effective cross section at $Q=600$ cumecs of 520 square metres. This canal is principally an earth structure and involved the excavation of 410,000 cubic metres of earth and 115,000 cubic metres of rock. Downstream of the canal, the river was dredged at three points (Tvättar Hällan, Backen and Ytterhiskeforsen) where about 670,000 cubic metres of sand and gravel were removed.

The construction of the discharge tunnel was begun from the two ends, and from a shaft sunk near the midpoint, so that four faces were worked at the same time. First a top heading was excavated over the entire length by a gang of twenty-two drillers and a foreman at each of the working faces, using steel scaffolds with platforms at three levels. Millisecond delay blasting removed 1100 cubic metres of rock at a time, which was loaded by heavy power shovels on to 14- and 20-ton dumper trucks. For the subsequent bench drilling jumbos mounting twelve drills each were employed, each drill being equipped with a motor-driven chain feed. A set of holes was drilled to a depth of 8m, then the jumbo was advanced by 1·6m and another row was drilled, until a pattern of five rows had been completed. The holes were then charged, the jumbo was withdrawn, and the charges were fired. By using centralised drill lubrication for each group of six drills, drill life, it is stated, could be prolonged from a few hundred metres to some 3000m. Following the driving of the tunnel, the rockfaces had to be trimmed smooth to reduce flow resistance. This work was greatly aided by the use of mobile stages, shown in Fig. 10, which had been specially designed by the State Power Board.

Machine Hall

The machine station (Fig. 7) is completely excavated from the solid rock, and access is obtained both to it and the transformer hall by a slightly sloping adit tunnel, as well as a lift. Provision has been made for the erection of a fourth generator set at a later date, when further regulation of the river has been carried out.





Figs. 10 and 11—(Left) Trimming the rock face of the discharge tunnel. Each of the special mobile scaffolds rests on three steerable swing axles fitted with two 12·00 by 24in tyres. The wheel base can be extended by moving the two front wheels. The upper boom can be raised through 160 deg., giving a working range of 10ft to 85ft above floor level. A 52 h.p. diesel-electric set supplies power for driving and steering, and compressed air and water for drilling and trimming. Control of the position of the stage is from the stage itself or from the vehicle. (Right) Stator frame being turned

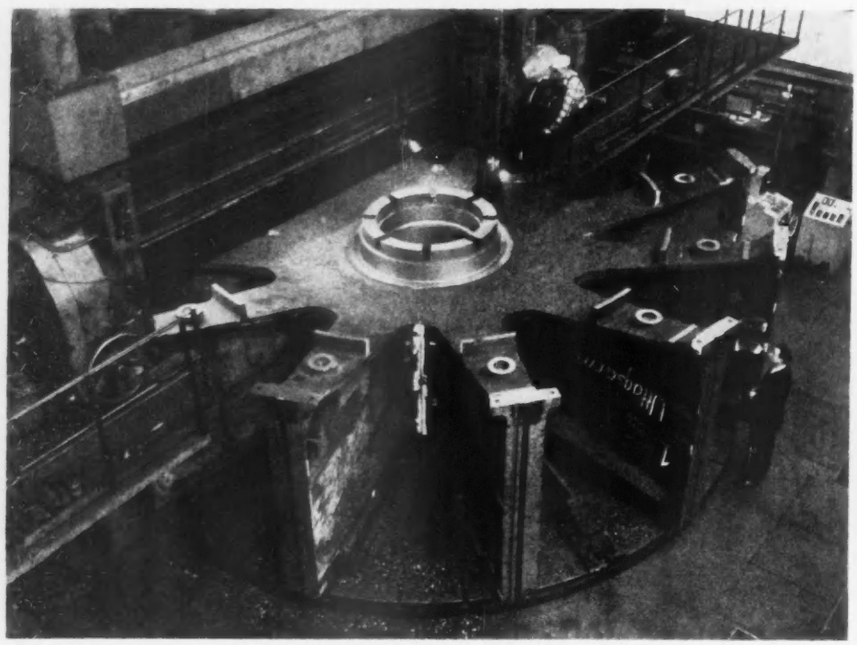


Fig. 12—Machining of generator spider

Maximum discharge of 600 cumecs is achieved with upstream water at 75m above sea level and the tailrace at 0·5m above sea level, giving a gross head of 74·5m. With water storage of 1390 million cubic metres, output in the mean year is 1950 GWh (10^6 units), and with a storage of 2840 million cubic metres, this rises to 2100 GWh.

The turbines are vertical, single-runner, Francis turbines. Our illustration (Fig. 8) shows one of the runners under construction. It has a diameter of 5m and weight of 67 tonnes; nevertheless, in spite of the large size and weight, it was possible to avoid a split design, as sea transport from the maker's works was available. The material was stainless steel, and although a single casting would have been possible, it was preferred to cast blades and hub separately and to assemble them by welding after the blades had been machined, which gave greater accuracy and a better surface finish.

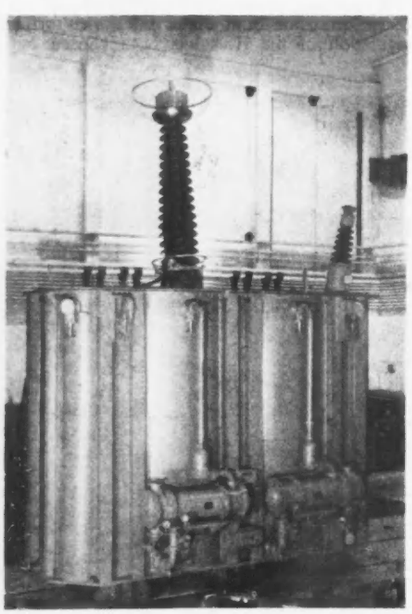


Fig. 13—One of the single-phase transformers with two 18kV, 100MVA primary windings and a secondary output of 200MVA, 380 $\sqrt{3}$kV. Oil cooling is by forced convection, two oil coolers being built-on

Because the owner had specified martensitic cast steel, a special procedure of welding and heat treatment had to be adopted. For reasons of lightness and homogeneity, the stayrings and head covers (Fig. 9) and other turbine parts, were fabricated from steel. For the main guide bearings, a self-lubricated design was employed.

The turbines were manufactured at the works of Nydqvist and Holm (NOHAB) at Trollhättan on the Göta river, and were shipped to Holmsund on the Baltic from where they were transported to the site on heavy trailers.

The directly-coupled three-phase generators were made by Asea of Västerås. Each is laid out for 150MVA at 18kV, 50 c/s, 125 r.p.m. Special problems arose on account of the great weight of these units which amounted to 925 tonnes. The rotor measures 9·75m in diameter, and has a spider (seen in Fig. 12) constructed of four bolted-up sections which carry the armature which consists of 14,000 plates. For lowering this large mass of 450 tonnes into the turbine pit, the load had to be spread over two travelling cranes. Fig. 11 shows the machining of one of the stator frames.

It is of some interest to compare the alternators with the equipment designed about ten years ago for Harsprånget (commissioned 1951) and Ligga (designed *ca*, 1951). At Harsprånget, three Asea generators of 105MVA at 167 r.p.m. were installed. The rotors of these sets weigh, with shaft, 465 tonnes, compared with 515 tonnes at Stornorrfors, although the output of the latter equipment is 50 per cent higher. This achievement was possible largely by a reduction in the transient reactance.

There are two main busbars, one for Nos. 1 and 3 generators, the other for No. 2 and, presumably for the future No. 4. These busbars feed the separate primaries of a group of three Asea single-phase transformers laid out for 600MVA, 18kV/(380/$\sqrt{3}$)kV (Fig. 13). A fourth similar transformer is installed as a standby. Each transformer weighs 225 tonnes.

The 18kV switchgear comprises 3-pole generator circuit breakers rated at 5050A, 2000MVA and 2-pole transformer circuit breakers rated at 6000A and 1800MVA. These are compressed air breakers made by Brown, Boveri. The station feeds into the Swedish 380kV supergrid. Quantities of materials are listed below.

Materials and Quantities at the Construction of Stornorrfors Power Station

Concrete	60,000 cubic metres
Cement	18,000 tonnes
Reinforcement steel	3000 tonnes
Structural steel	3500 tonnes
Shuttering	80,000 square metres
Earth excavation	2,450,000 cubic metres
Rock excavation...	2,600,000 cubic metres

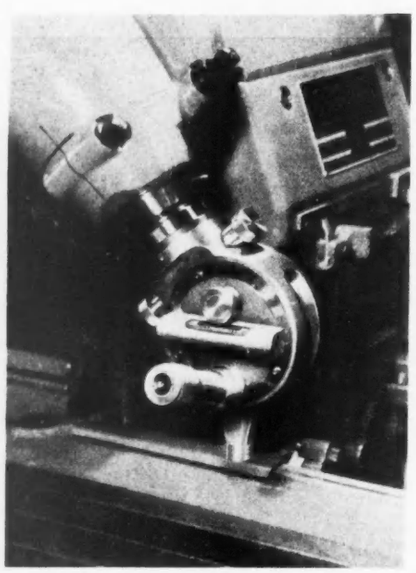
European Nuclear Research in Norway

On June 11, representatives of a number of European countries and Euratom concluded an agreement for the joint operation of Norway's 10MW Halden experimental boiling water reactor. Austria, Denmark, the Euratom Commission, A.B. Atomenergi of Sweden, Switzerland and the United Kingdom Atomic Energy Authority agreed to join with the Norwegian Institut for Atomenergi—the builders and owners of the reactor—in carrying out a joint programme of research and experiments over a three-year period beginning July 1, 1958. This agreement is subject to the necessary funds being made available by the appropriate authorities.

The reactor, situated 120km south of Oslo, is the only boiling water reactor in Europe and the first heavy water boiling reactor in the world. A budget of the order of 4,000,000 dollars is envisaged for the joint programme, designed to study the scientific and technical problems related to this reactor design. An International Committee will approve the joint programme and a Technical Group will supervise its execution. The Norwegian Institute will carry out the programme with a staff recruited from the participants. Representatives of the United States Government also took part in the discussions leading to the Agreement, and have offered American collaboration in the joint programme, with specialists and the exchange of information.

Optical Goniometer

A goniometer designed in particular for the accurate setting of universal milling heads or machine tool supports, is being put on the market by Gebr. Miller G.m.b.H., of Innsbruck. The instrument, which is shown in the accompanying illustration, is fitted to the milling spindle in place of the cutter by means of a standard morse or ISA taper (equipped with a push-off nut for removing the instrument again), and can



Goniometer for setting the angle of universal milling heads. The instrument is fitted to the auxiliary spindle, the scale being read by means of a graduated eyepiece

be swivelled about the spindle axis and clamped at any angle by an eccentric. Three centring screws allow the instrument to be set accurately on the spindle axis. The head, which carries a precision level, can be swivelled through ±90 deg., readings being taken by means of a 50× microscope with graduated eyepiece. It is stated that settings to 0·003 deg. can be made. In order to check the parallelism of the milling head and the dial, the instrument is provided with a telescope of 20× magnification.

National Metal Congress and Exposition

No. 1

BY OUR AMERICAN EDITOR

THE Fortieth National Metal Congress and Exposition was held in Cleveland, Ohio, from October 27 to 31. As in previous years, it was sponsored by the American Society for Metals, the Institute of Metals Division of the American Institute of Mining, Metallurgical and Petroleum Engineers, and the Society for Non-Destructive Testing. About 400 companies engaged in either the production, treatment or fabrication of metals, gave displays and demonstrations of their products or services at the exhibition, which was held at the Cleveland Public Auditorium. Over the years, the Metal Show has continued to become ever broader in its coverage of the metals and metal working field, and gone are the days when it was concerned mainly with the heat-treatment of steels. This year there was again a strong accent on the fabrication and application of some of the more recently developed metals, such as beryllium, molybdenum, zirconium, columbium and tantalum. Among the trends to be noticed at the Metal Show were an increasing number of powder metallurgical products and processes; greater uses of ultrasonic techniques in the fields of non-destructive testing, metal cleaning and metal joining; an accent on "automation" applied to a variety of metal processing plant; and a growing popularity of vacuum melting furnaces and other vacuum processing equipment.

As part of this year's Congress, the American Society for Metals sponsored a seminar on "Magnetic Properties and Alloys," with a special address by Dr. G. W. Rathenau of the University of Amsterdam on "Time Effects in Magnetisation." Another major event was a special A.S.M. three-day "Seminar on Residual Stresses," held at the Wade Park Manor, under the leadership of Professor Richard Weck, of Cambridge University. Also held this year was the first of the "William Park Woodside Panel Conferences." Honouring the memory of an A.S.M. founder-member, these conferences are emphasising practical problems and techniques, including the revolutionary new explosive forming and chipless machining processes.

At the annual banquet, the A.S.M. Gold Medal was presented to Dr. Albert J. Phillips, vice-president and director of research of the American Smelting and Refining Company; the A.S.M. Medal for the Advancement of Research to Crawford H. Greenewalt, president of the E. I. DuPont de Nemours Company; and the Albert Sauveur Achievement Award to William G. Pfann, physical metallurgist at the Bell Telephone Laboratories. Also at the banquet, Ernest E. Thum, editor-in-chief of the A.S.M. journal, *Metal Progress*, was made an Honorary Member of the Society. At the annual Awards Luncheon the speaker was Kenneth Headlam-Morley, secretary of the Iron and Steel Institute, whose topic was "An Englishman Looks at the American Steel Industry." Awards at the luncheon presented by the A.S.M. included the Henry Marion Howe Award to Dr. George Gerard, assistant director of the New York University College of Engineering, and Ralph Papirno, research scientist in the N.Y.U. College of Engineering.

1958 Gregory Award

At the Awards Luncheon, the 1500-dollar Gregory Award, for contribution to the development of electric arc stud welding, was conferred upon Dr. J. C. Chapman, of the Civil Engineering Department, Imperial College of Science and Technology, for his paper on "The Application of Stud Welding to Vibrating Wire Strain Gauges." This type of strain gauge has been used in several different forms and has a reputation for its long-term stability and reliability. The gauge makes use of the variation with tension of the natural frequency of vibration of a taut wire. The wire is "plucked" by means of an electromagnet and the same magnet then acts as a pick-up to signal the free vibration of the wire to an oscilloscope. A known variable frequency can then be matched against that of the strain gauge wire, and the change of strain in the structure to which the wire is attached can thus be inferred. In principle, therefore, the gauge is simple and reliable. In practice, the difficulty is to attach the taut wire to the structure in such a way that the strain in the structure is faithfully transferred to the wire. There must be no relative movement between the wire anchorages and the structure, even when the strain in the structure fluctuates and perhaps alternates between tension and compression. An anchorage movement of one-thousandth of an inch, on a 6in gauge length, would falsely indicate a stress change of more than 2 tons per square inch.

A gauge had been described by R. J. Mainstone, in which the wire is anchored by posts which are screwed to the structure. The disadvantages of this design are: (1) The screwed-in posts may change their setting slightly as the structure is strained. Furthermore, the effective gauge length may vary from gauge to gauge. (2) The structure must be drilled and tapped. This is a tedious operation and may be structurally undesirable in some cases. (3) Owing to the difficulty of drilling and tapping holes in the structure, the magnet is fixed internally to the gauge cover, which itself is fixed only by small screws. The distance between the wire and magnet is therefore only roughly determined, and also the cover is liable to be dislodged during construction. It appeared that these shortcomings of an otherwise excellent gauge could be overcome by stud welding. The wire could be anchored to robust studs which would then be monolithic with the structure; the studs could be correctly oriented without difficulty. The magnet assembly could be mounted from threaded studs below the wire, so that the clearance between wire and magnet could be easily and exactly adjusted. Finally, the gauge cover could be robust and fixed by studs of compatible strength. Each array of six studs could be quickly and accurately placed by means of single template. As the gauges were required in the first instance for an investigation on a building designed compositely with welded stud shear connectors—the first project of this kind in Great Britain—it seemed appropriate that welded studs should also be used for the gauges.

As illustrated on page 640, THE ENGINEER, October 24, 1958, the gauge posts are $\frac{5}{8}$in studs, $1\frac{1}{4}$in long. A $\frac{1}{8}$in slot is milled to accommodate a $\frac{1}{4}$in by $\frac{1}{8}$in bar to which pressure is applied by an Allen screw. By this means the wire is clamped between the bar and the bottom of the slot. An external lock nut is provided to prevent spreading of the slot by the Allen screw, whilst at the same time locking the screw and bar. The slotted studs enable a special wire straining device to be used in which the wire is correctly tensioned in a frame and then placed between the slots. The wire can then be clamped, using constant torque spanners, and finally snipped at its ends to release it from the straining frame. Since the pressure is applied concentrically to the clamping bar, the wire is uniformly clamped across the whole diameter of the stud, so that the free length of the wire is precisely defined. The gauge posts are correctly aligned with the welding gun by a tongue within the chuck which locates in the slot in the post. As shown in Fig. 1, the gun is aligned with the template by locating the tripod studs in holes in the template, the chuck having previously been oriented by inserting the tongue in the slot of a dummy post with surrounding holes. The electromagnet is mounted by $\frac{1}{4}$in studs and the cover is fixed by $\frac{1}{2}$in studs. By using the same template for locating the six studs, the positions of the electromagnet and the gauge cover are correctly fixed in relation to the wire. The "Nelson" stud welding equipment used was type E/3D with rectifier type TRF 6.

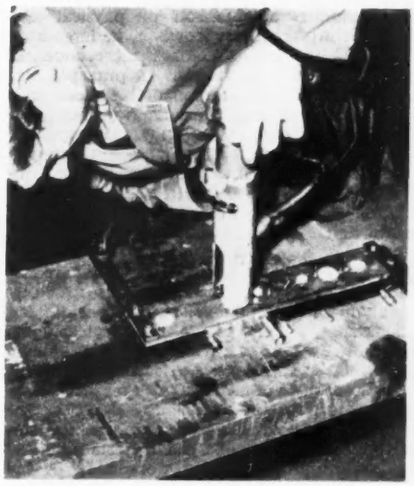


Fig. 1—Template used in the placing of the studs

The cast iron cover has a compartment which enables the armoured cable to be connected to the leads from the electromagnet after the cover has been fixed and sealed. A rubber gasket is provided between the gauge cover and the structure; this serves both to seal the cover and to isolate it structurally from the component to which it is attached. For the same reasons there are also rubber washers beneath the cover fixing nuts, and rubber grommets around the fixing studs.

It was desired to record the complete strain history of the steel frame members which were to be instrumented, and the gauges were therefore fixed to the members before erection. Owing to the congestion of the building site, the steelwork was available for instrumentation for only a short period before erection; as only two technicians were available for gauge fixing it was essential that the gauges should be capable of very rapid adjustment and assembly. The experience of investigators using other gauge designs was not encouraging in this respect,

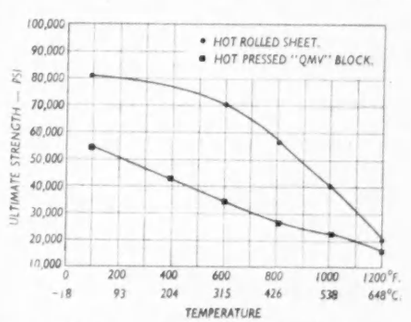


Fig. 2—Variation of tensile strength with temperature for hot-pressed and hot-rolled beryllium

assembly rates of three or four gauges per day being mentioned where there was little experience of the idiosyncrasies of the gauge. Owing to late delivery of electrical components, the assembly of the stud-welded gauge had not been rehearsed before the arrival of the steelwork on site. Furthermore, to meet the construction schedule the first batch of forty-two gauges had to be stud-welded, adjusted, and completely assembled in two days. This task was completed on time, as were the later stages of gauging. Over 100

gauges were fixed to the steelwork before erection, and all were operative after the completion of the structure.

Brush Beryllium Company

Many interesting industrial components made of pure beryllium were exhibited by the Brush Beryllium Company, of Cleveland, Ohio. This firm is now the major producer of the metal in America, both for Government and civilian applications. Already before the last war, it became apparent that unalloyed beryllium had an unexcelled combination of physical and mechanical properties. However, its large-scale use depended on two factors : the economical reduction of the metal from its principal ore, beryl ; and the preparation of the metal in a form that would permit maximum realisation of its excellent mechanical and physical properties.

Metal reduction is accomplished to-day by various processes developed by the firm. Impurity removal steps are performed in the formation of beryllium hydroxide and the subsequent conversion to ammonium-beryllium-fluoride. After this high purity fluoride is thermally reduced to beryllium fluoride, magnesium reduction isolates beryllium metal, which is treated by vacuum casting to remove residual fluorides and magnesium. The vacuum casting technique, used primarily for the final removal of volatile impurities, has not yet been successfully developed as a source of metal suitable for machining, rolling, forging and extrusion. Large crystal size, shrinkage cavities and pipe, and the anisotropic nature of the beryllium crystal limit the mechanical properties and workability of the cast metal. Continuing research into methods of casting pure beryllium will undoubtedly result in improved and practical techniques.

The recent American developments in the use of beryllium metal and the determination of its excellent engineering properties are due largely to the production of improved beryllium by the " QMV " process developed and patented by the Brush Beryllium Company. The process uses high-purity vacuum-cast beryllium ingots as the starting material. The ingots are mechanically reduced to chips, then attritioned to form a carefully graded powder. The powder, protected against contamination throughout the processing, is hot-pressed under vacuum, and sintered to form a solid high-density block which becomes the basis for further fabrication. These hot-pressed shapes, up to 65in in diameter, are machined, rolled, extruded and forged to form beryllium components as required. All methods of fabrication are being used on an experimental basis, and many are in production.

Present casting methods produce a metal with an ultimate tensile strength of only 25,000 lb per square inch, while sintered " QMV " metal has an average ultimate tensile strength of 45,000 lb per square inch and greatly improved ductility. The hot-working of " QMV " beryllium further improves the tensile value to a 75,000–125,000 lb per square inch range. Fig. 2 shows the variation of ultimate tensile strength with temperature for hot-pressed and hot-rolled beryllium. The most notable recent contributions to beryllium technology have been the improvements in strength and ductility due to the use of the " QMV " process, and later to the development of hot working techniques for rolling and extrusion.

When ultimate tensile strength is divided by the specific gravity of a material, it is possible to obtain a more accurate evaluation of the usefulness of the material compared with " competitive " metals. This is particularly valuable in the design of high-speed airborne devices and rapidly moving components, where economy of motive force and dimensional stability are important. As shown in Fig. 3, wrought " QMV " beryllium has the highest strength-to-weight ratio of the commonly used structural materials. Beryllium maintains this superiority at temperatures up to 1200 deg. Fah.

Stiffness is an important factor in airframe design, where structural members are reduced in thickness to save weight. With a high degree of stiffness, the frequency of vibrations produced by deflections may be increased well above critical limits for the design and material used. Rigidity rather than strength is the prime design consideration for many aircraft structural components. Using most high-strength design materials, this emphasis on rigidity results in an overweight section, with higher strength than required. The high modulus of elasticity of beryllium ($44 \cdot 0 \times 10^6$) makes the design of light weight rigid components practical. Solid beryllium components are superior to most " honeycomb " structures in stiffness-to-weight ratio. Solid beryllium sections can be produced at a lower cost than stainless steel honeycomb components, and can be machined to complex shapes by simple machining operations as compared to the complex procedures necessary to develop contours in the built-up structures.

Beryllium has unusually high heat absorbing properties, combining high heat capacity with high thermal conductivity and high melting point. While this quality will undoubtedly open many industrial applications, it is particularly important in the design of aircraft and airborne instruments where weight is also a factor. The combination of structural properties with high heat-absorbing quality indicates beryllium as a possible solution to atmosphere re-entry problems. Beryllium is now being evaluated for use in instrument bases, braking devices and leading edges of hypersonic aircraft wings.

Until this year the largest usage of " QMV " beryllium has been in nuclear reactor applications. Beryllium is unsurpassed as a reflector of thermal energy neutrons and has been widely used in nuclear testing reactors throughout the world. Beryllium is also an excellent moderator. The use of beryllium effects a real economy of neutron production, due to the reaction which generates neutrons into the reactor system, compensating for neutrons absorbed. The light weight and high strength of beryllium, and its availability in a wide variety of structural forms, result in an overwhelming weight advantage when beryllium is used in portable and airborne power reactors.

The integrated facilities of the company have a capacity for beryllium as vacuum cast ingot of 10,000 lb to 15,000 lb per month. " QMV " block is the starting material for all fabrication of beryllium, and can be supplied in shapes up to 65in diameter, weighing up to 2500 lb. Brush has also undertaken the development of extrusion techniques for beryllium. Both hot-extrusion and warm-extrusion have proven successful, with properties varying somewhat depending on the amount of work imparted to the metal, but generally paralleling the properties of hot-rolled sheet. Beryllium tubing extruded in various sizes and wall thicknesses has filled many structural requirements. Recent evaluation indicates the practicability of tubing extrusion in diameters up to 18in, for requirements in missile applications. The extrusion of standard structural shapes and special sections is under investigation. These studies clearly indicate the feasibility of developing standard production shapes and size of beryllium extrusions.

The largest potential for the future use of beryllium appears in the form of sheet and plate for fabrication into lightweight assemblies. Continuous commercial and Government-sponsored development is carried out to arrive at the best technique for the production of aircraft-size sheet with progressively improving properties. Hot-rolled sheet and plate are now commercially available from the company in the following size ranges :

Gauge	Sheet size
0·080in and up	30in by 60in
0·040in to 0·080in	20in by 60in

It appears that size and design of equipment will be the only limiting factors in the production of large sheet widths and lengths. Current development also is aimed at the production of thin gauge strip in increased lengths for application in " built-up " component construction and evaluation as a honeycomb core material. Beryllium sheet has been formed into a variety of shapes using modifications of standard sheet-forming techniques. Components now being made of other metals by roll-forming, stretch-forming, die-forming, shear-forming and stamping can now be considered in beryllium. Experienced airframe component fabricators are using modified production forming methods to form beryllium into shapes utilising the unique properties of the metal to great advantage.

Foamalum Corporation

A recently developed material called " Foamalum " was shown at the stand of the Foamalum Corporation, of LaSalle, Illinois. While the product is referred to as foamed aluminium, its makers can, and normally do, foam any of the various aluminium alloys rather than pure aluminium. Different alloys, however, have different foaming characteristics, and one alloy may differ from another in its ability to be produced in the lighter densities.

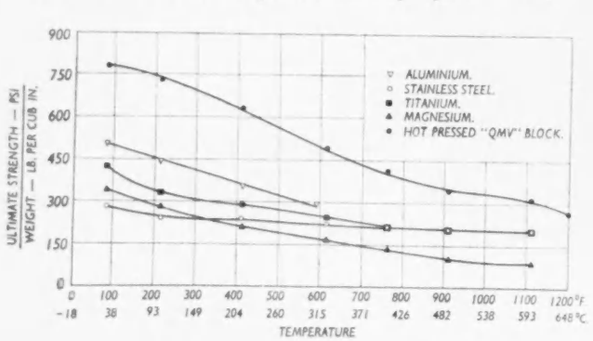


Fig. 3—Variation of strength-to-weight ratio with temperature for beryllium and various structural materials

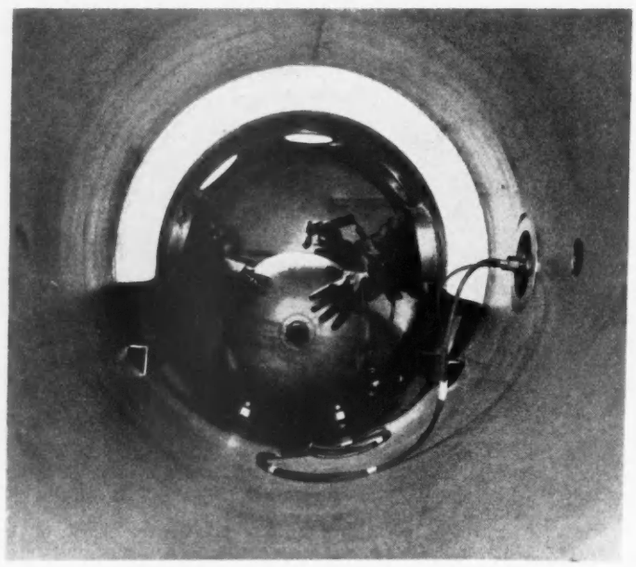


Fig. 4—Tantalum-lined stainless steel reactor vessel for operation at 650 deg. Fah. and 500 lb per square inch

Foamalum can be cast into fairly intricate shapes with a reasonable control in density between 20 lb and 70 lb per cubic foot, as compared to the 166 lb per cubic foot density of ingot aluminium. In the casting process a "skin" of comparatively smooth aluminium is formed where the mould is touched and there is a core of foamed aluminium, the cells being smaller near the surface of the casting. All cells or bubbles are not of the same size, but are more nearly constant in the heavier densities. The extreme lightweight product (under 20 lb per cubic foot) is obtained by removing the heavier skin surface from the casting by sawing or machining. Castings are being made in various permanent moulds, sand moulds and shell moulds.

As far as is now known, the physical properties of the product will vary according to the alloy used, and for any given alloy the tensile and compressive strength are nearly proportionate to the weight of the foam as compared to the weight of the ingot metal. Foamalum has good rigidity, but no exact measurement has been obtained as yet. It also has good malleability. It floats in water, not because of its skin surface, but because a major portion of the cells or bubbles are closed and will not absorb water, even with the skin removed from the casting. Foamalum may be pressed into various shapes without destroying the cell structure—it merely changes the shape of the cell: there is little or no splitting or shattering of the material.

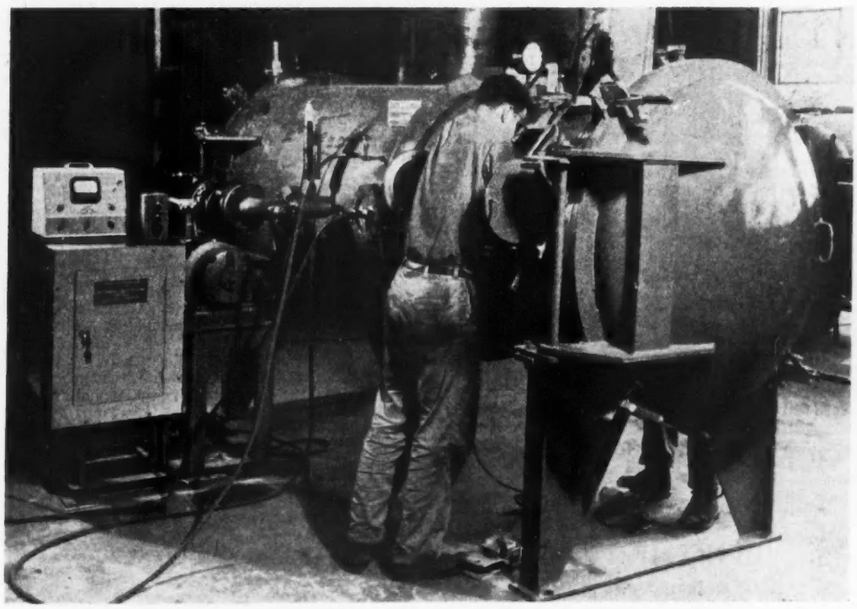


Fig. 5—Welding of tantalum liner into reactor vessel, working within a vacuum purge dry box

It is interesting to note that as the material is compressed, it picks up strength, and preliminary tests with softer, less brittle alloys, indicate that original ingot strength is obtained when only half of the original density has been reached. If further tests confirm this to be consistently true this characteristic will have far-reaching implications. The material may be machined, cut with a common band saw, nailed through, bolted, glued to other objects, screwed into, bent or pressed into shape. A test on one sample showed the thermal conductivity, in a density of 40 lb per cubic foot, to be 17·7 B.Th.U. in per square foot per hour per deg. Fah. This compares with 1450 B.Th.U. in per square foot per deg. Fah. for solid aluminium.

Specific applications of the new material include core material for doors, laminated panels and various sandwich panels, acoustical ceiling tile, wall panels, store fronts, and various other construction uses such as docks and piers and sign boards.

Union Carbide Corporation

The display of the Union Carbide Corporation, of New York, stressed industrial applications of such relatively rare metals as tungsten, chromium, columbium, tantalum, vanadium and titanium. The Haynes Stellite division of the firm contributed a particularly interesting reactor vessel, which is shown in Fig. 4. The entire inner chamber of this vessel is lined with tantalum, a metal that is practically inert to corrosion from just about all common acids. The vessel is believed to be the largest of its kind ever made which utilises the exceptional corrosion-resistant characteristics of tantalum. Two of the important developments in recent years regarding tantalum metal are the availability of larger sheets and improved welding characteristics. Haynes Stellite has been engaged in the development of production facilities for making tantalum by the consumable electrode process. Formerly, the maximum weight available in a swaged bar was 25 lb. The new method produces a larger ingot, which, of course, will allow the production of larger sheets. At the present time, sheet up to 24in wide and 60in long has been produced. To the chemical process industry this means that equipment will soon be available that will offer almost absolute corrosion resistance to most known acidic corrosives up to the limit of the test temperatures used to-day. The vessel on display was a 30-gallon unit designed to operate at 650 deg. Fah. and 500 lb per square inch. The base material was Type 430 stainless steel, $\frac{5}{8}$in thick, with an 0·030in lining of "Haynes" tantalum. A tantalum-sheathed agitator shaft with a solid tantalum agitator was part of the inside equipment. Every part of the vessel that will come in contact with the product was either made of, or sheathed with, tantalum. The overall weight of the assembled vessel was about 700 lb, without the drive mechanism. Fig. 5 shows sections of the tantalum liner for the reactor vessel being joined by welding inside a vacuum purge "dry box." The work area was evacuated first and then back-filled with an inert gas so that all welding was done in an atmosphere free of contamination. The operator worked within a vacuum chamber through rubber gloves that extended through the side walls.

Vanadium-Alloys Steel Company

A new range of pre-alloyed steel powders were shown by the Vanadium-Alloys Steel Company, of Latrobe, Pennsylvania. These powders were developed for the purpose of bringing the advantage of iron alloys to the metal powder field. Previously, alloys were made by mixing powder of the desired alloying element with iron powder. Because of slow solution rates and the abnormal sintering times required to provide even partial alloying, such alloy mixtures were not used commercially. With the introduction of pre-alloyed powders, where the alloying elements are introduced by melting, the use of alloy powders is quite practical.

The firm's pre-alloyed steel powders are produced by atomisation of molten metal having the desired chemistry so that each powder particle is a tiny ingot with the composition of the melt. These powders are produced by a patented process in a modern plant especially designed for the purpose. The process itself is very flexible and permits making pre-alloyed powder of any composition that can be melted. Powders being produced include stainless steels of all types, heat treatable alloy steels and special purpose alloys, including brazing alloys, high temperature alloys and alloys for magnetic and electrical applications. All pre-alloyed powders are available in the standard 100 mesh U.S. sieve particle size and in other special mesh sizes ranging from −20 to −325 mesh in fineness. The applications include high strength parts produced from heat treatable alloy steel powders, machine components and filters from stainless steel powders, corrosion and wear-resistant coatings from stainless steels and special purpose alloys. The machine components and some filters are fabricated by moulding and sintering, followed by heat treating in the case of the high strength parts. Other filters are made by loose powder sintering.

The stainless steel powders are identified by the A.I.S.I. number corresponding to the composition. Types 302-B and 316 are standard powder grades. Types 347, 310, 410 and 420 are some of the special grades produced. The 300 series powders are produced in two particle shapes: an irregular shape and a regular shape. The irregular powder contains a nominal 2·5 per cent silicon while the regular powder carries a nominal 1·0 per cent silicon. The high silicon improves moulding and sintering characteristics in the powder and increases ductility, tensile strength and oxidation resistance in the sintered parts. The company's 4600-A alloy steel powders are manufactured to meet the demand for a heat treatable alloy steel powder that can be readily worked. Produced to the basic A.I.S.I. 4600 analysis, these powders are available in various carbon contents to meet customer requirements. Both standard carbon contents, 4630-A and 4650-A, are used commercially to produce high-strength parts. These powders with high hardenability, wide latitude in heat treatment and good mouldability, permit the fabrication of high-strength parts measuring over $\frac{1}{4}$in in thickness.

(*To be continued*)

Underground Furnace

Plans for building a 60,000 square foot engineering and research building and a huge furnace for heat treating and brazing missile components have been announced by Solar Aircraft Company, San Diego, California.

Both the new engineering building and the furnace facility will be built on Solar's bayfront leasehold in San Diego. Construction on the furnace—largest on the west coast and one of the largest in the U.S.—will start this month. Construction on the engineering building will begin early in 1959. The modern engineering and laboratory structure will provide a 50 per cent increase in space for the research and engineering departments to allow for scheduled expansion of those activities.

Solar's new furnace will be 31ft deep and 15ft in diameter, and will be almost entirely below ground. The shaft will extend below the water level of the adjacent bay, and will require special construction techniques. The furnace will handle missile fuel tanks and other components up to 9ft in diameter and 30ft long. Temperatures of the 1000kW furnace will reach 1950 deg. Fah. The building housing the furnace will be 50ft high.

In designing the new furnace, provision has been made for additional below-ground oil quench and air quench units and for a vertical above-ground heat treat and brazing unit.

Personal and Business

Appointments

MR. D. D. TEASDALE has been appointed chief accountant of Fawcett Preston and Co.

MR. G. N. VANSITTART has been appointed a director of Production Tool Alloy Company, Ltd.

MR. H. W. BURBERY has been appointed principal of the school of oil firing of Nu-Way Heating Plants, Ltd.

MR. R. E. GARDINER has been appointed London manager of Alldays and Onions, Ltd., in succession to Mr. R. J. Nash.

HADFIELDS, Ltd., announces the appointments of Mr. Fred Cousans, Mr. George Wood and Mr. R. C. Heys as directors.

SIMMS MOTOR AND ELECTRONICS CORPORATION, Ltd., states that Mr. Alan Hess has been appointed public relations manager.

MR. E. MARLAND has been appointed commercial manager of the capacitors and resistors division of the Plessey Company, Ltd., at Swindon.

MR. HENRY L. HIRCHBERG has been appointed director and works manager of Ediswan-Ekco (CRT) Company, Sydney, New South Wales, Australia.

MR. FRED WALKER, methods engineer of the Dunlop Rubber Company, Ltd., at Fort Dunlop, has been appointed manager of the overseas engineering department.

LLOYD'S REGISTER OF SHIPPING has announced that Mr. A. W. E. Happé has been appointed editor of publications in succession to the late Mr. W. H. Carslaw.

MR. ARNOLD CARR, assistant managing director of Thos. W. Ward, Ltd., has been appointed deputy chairman. Mr. Douglas F. Walton has been appointed a director.

THE JUNIOR INSTITUTION OF ENGINEERS announces that Mr. W. C. C. Ball has been elected chairman, and Mr. E. M. Baskerville and Mr. E. E. Burrage, M.I.Mar.E., vice chairmen.

MR. W. D. Cartwright has been appointed field sales executive of Steels Engineering Products, Ltd., and will be attached to the staff of the home sales director at Sloane Street, London, W.1.

G. A. HARVEY AND CO. (LONDON), Ltd., has made the following staff appointments : Mr. K. Tardif, home sales manager ; Mr. H. Barker, exports sales manager, and Mr. H. F. Jones, London area manager.

THE BRITISH BROADCASTING CORPORATION announces that Mr. D. T. Feek has been appointed engineer-in-charge of its new television and V.H.F. sound broadcasting station at Thrumster, near Wick.

THE NATIONAL STEEL FOUNDRY (1914), Ltd., has announced the appointment of Mr. A. A. Marsh as a personal assistant to the managing director. Mr. J. G. Simonson, director and general manager, is to retire on December 31, but will continue as a director and technical adviser to the company.

SIMON-CARVES, Ltd. has announced the following appointments to the board of its subsidiary company, Lodge-Cottrell, Ltd. ; Mr. J. P. V. Woollam, M.I.Chem.E., chairman ; and Mr. R. B. Potter, M.I.Mech.E., Mr. N. Hinton and Mr. P. D. Taylor, directors. Mr. D. H. Richards, managing director, and Mr. H. G. Trevor Busby and Mr. E. R. Watkins, executive directors, will retain their previous appointments.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has announced the following appointments : Mr. E. W. Stainton, A.M.I.E.E., assistant sales manager, switchgear department ; Mr. D. R. Clegg, Grad. I.E.E., assistant sales manager, transformer department ; Mr. F. H. Davis, assistant superintendent foundries, and Mr. D. E. Thornhill, assistant superintendent, transformer department, Wythenshawe.

ELGAR MACHINE TOOL COMPANY, Ltd., has announced that Mr. T. E. Parkinson has been appointed a director and will act in the capacity of general sales manager. Mr. G. H. C. Goodban has been appointed a director of the Press and Shear Machinery Company, Ltd., and will be responsible for sales and general management of that company. He remains a director of Elgar Machine Tool Company, Ltd.

THE MINISTRY OF SUPPLY announces the following appointments : Mr. W. H. Stephens, director-general, ballistic missiles ; Mr. S. F. Follett, deputy director, Royal Aircraft Establishment, Farnborough, in succession to Mr. Stephens ; Mr. L. T. D. Williams, director-general, Ministry of Supply staff, British Joint Services Mission, Washington, in succession to Mr. Follett ; and Mr. J. H. Phillips, director, guided weapons (techniques).

MR. G. D. ELLIOT, O.B.E., has been appointed deputy general works manager of Appleby-Frodingham Steel Company, a branch of the United Steel Companies, Ltd., with effect from January 1, 1959. He will succeed Mr. J. D. Joy as general works manager on April 1 next. Mr. Joy has been appointed deputy general manager of the company from January 1. Mr. N. D. MacDonald will succeed Mr. Elliot as works manager.

Business Announcements

MR. H. S. HORSMAN, M.I.Mech.E., efficiency and testing engineer of the Central Electricity Generating Board, is to retire at the end of the year.

BRITISH RAILWAYS, LONDON MIDLAND REGION, announces that Mr. J. Taylor Thompson, M.I.C.E., is to retire on December 31 from the position of chief civil engineer.

MR. W. ROY BISHOP has resigned from his position as sales manager and director of J. A. Prestwich Industries, Ltd., and also his connection with the Villiers Engineering Company, Ltd.

T. B. PEARSON AND SONS, Ltd., of Walker, Newcastle upon Tyne, states that it has formed a separate company, Pearson Machine Tool Company, Ltd., to handle its machine tool activities.

THE BRITISH INSTITUTION OF RADIO ENGINEERS, 9, Bedford Square, London, W.C.1, has announced the formation of a Medical Electronics Group. Mr. W. J. Perkins is chairman of the group committee.

SULZER BROS. (LONDON), Ltd., announces that it has concluded an agreement with the De Havilland Engine Company, Ltd., Leavesden, Herts, for the manufacture by the De Havilland Company of the Sulzer supercharger for diesel rail traction purposes.

MESSRS. GREEN AND FOX, consultants, 13, Clarence Drive, Englefield Green, Egham, Surrey, announce that in order to devote the whole of his time to their interests, Mr. W. A. Green has resigned from his seat on the board and severed his connection with Bryce Berger, Ltd., Staines.

Contract

RICHARD COSTAIN, Ltd., has been awarded a £400,000 contract for building Lewisham's biggest post-war estate. The scheme consists of three 11-storey blocks of flats and five 4-storey blocks of maisonettes, and will provide 132 flats and forty maisonettes in Eltham Road, and the contract for the Metropolitan Borough of Lewisham (M. H. Forward, F.R.I.B.A., F.R.I.C.S., Borough Architect). The contract is expected to be completed in July, 1960. The 11-storey blocks are to be in reinforced concrete column and beam construction with panel walls, with r.c. flat roofs and aluminium pitched roofs.

Miscellanea

CORYTON REFINERY.—We are informed by the Mobil Oil Company, Ltd., that the first stage of the large liquefied petroleum gases recovery unit being built at Coryton refinery by Constructors John Brown, Ltd., will be ready in January, and start separating propane from the refinery gases. Later, butane will also be separated by the plant.

TECHNICAL ABSTRACTS ON LEAD.—A new publication of the Lead Development Association gives abstracts of relevant information from current literature on lead. A second section of the publication sets out brief information on new patents on the subject. The Association will send the publication to interested firms and individuals on application to its office at 18, Adam Street, London, W.C.2.

MACHINE TOOL DEMONSTRATION.—It is announced by Sidney G. Jones, Ltd., 8, Balham Hill, London, S.W.11, that it is proposed to hold a demonstration of machine tools at the Midlands Electricity Board's Industrial Showrooms, 247, Chester Street, Aston, Birmingham, 6, for the two weeks commencing January 5, 1959. The Fraser range of "Endomatic" spotfacing and centring machines to be shown will include a round table drilling machine and various unit heads.

QUALITY CONTROL EQUIPMENT.—We are informed that quality control equipment, the "Technicon Autoanalyser," is being manufactured by Technicon Instruments Company, Ltd., 26, Warwick Road, London, S.W.5. The equipment consists of a series of modules, variable in accordance with processing requirements and provides, through continuous chemical analysis, continuous control of product composition. The autoanalyser has the ability to isolate constituents in process streams and thus affords quality control during production.

WRECK RETURNS.—The returns of merchant ships totally lost, broken up, &c., published by Lloyd's Register of Shipping for the quarter ended March 31, 1958, indicates that five ships of 8864 gross tons owned in Great Britain and Northern Ireland were lost subsequent upon casualty out of a world total of forty ships of 85,988 tons. The corresponding totals for ships broken up are given as twenty-seven ships of 50,815 tons and ninety-three ships of 287,680 tons respectively.

SHEET METAL WORKING MACHINE DEMONSTRATION.—The Press and Shear Machinery Company, Ltd., is to hold an exhibition and demonstration of sheet metal working machines in the showrooms at 172–178, Victoria Road, Acton, London, W.3, from January 19 to 23, 1959. Amongst the machines on view will be a Bohner and Kohle heavy duty hydraulic copy spinning and flow forming lathe ; Ebu open fronted mechanical presses ; and Banning electro-hydraulic automatic tube bending machines.

RADIOGRAPHS OF ALUMINIUM WELDS.—The British Welding Research Association has issued a booklet H3/58, entitled "Classified Radiographs for Defects in Aluminium Fusion Welds," which shows how to identify those defects in aluminium fusion welds which can be seen in radiographs. The booklet classifies defects, explains their origins and puts forward suggestions for their prevention. Five groups of defects are recognised and general indications are given of the ways in which defects influence joint properties, while a system is included for recording the severity of uniform porosity and its probable effect on joint efficiency.

EXHIBITION OF HIGH TEMPERATURE IN INDUSTRY.—An exhibition dealing with high temperature in industry by electricity has been organised by the Morgan Crucible Company, Ltd., Battersea Church Road, London, S.W.11, in collaboration with the Midlands Electricity Board and is being held in the Board's showrooms, 247, Chester Street, Aston, Birmingham, from December 8 to 19. Five different furnaces will be demonstrated to illustrate the diverse applications of "Crusilite" heating elements. Two small experimental mock-up furnaces will also be shown and there will be a display of the complete range of the company's elements.

CERTIFICATE OF ORIGIN OF NATURAL ROCK MASTIC ASPHALTE.—Mastic asphalts for building are of two types—natural rock and limestone—covered by separate British Standards. When delivered to site in cast blocks it is difficult to distinguish easily between the types and, therefore, the Natural Asphalte Mine-Owners and Manufacturers Council has introduced a Certificate of Origin of Natural Rock Mastic Asphalte. The approximate coverages for various thicknesses are given on the certificates, the terms of which have been approved by the British Standards Institution. Specimens are available from the Council at 94–98, Petty France, London, S.W.1.

PITCH CONTROLLED TAPPING MACHINES.—Pitch controlled tapping machines now being made in five models by W. J. Meddings, Ltd., Ipswich Road, Trading Estate, Slough, Bucks, are suitable for tapping a range of threads from 10 BA to ¼in in steel, ⅜in in brass and ½in in aluminium. These machines use interchangeable lead screws and nuts in a pitch control attachment at the front of the head. The top and bottom of the tapping stroke are determined by micro-switches which are operated by cams on the attachment and the tapping and withdrawal cycle are automatic after a start button has been depressed. The heads of the machines are driven by ¾ h.p. motors giving eight spindle speeds from 80 to 1500 r.p.m. and the spindle has a travel of 3in.

FILM ON GEAR MANUFACTURE.—A recent addition to the large number of interesting industrial films produced by Shell-Mex and B.P., Ltd., is entitled "An Introduction to Gear Manufacture." This film was produced with the assistance of several leading British manufacturing concerns, and Dr. H. E. Merritt co-operated as a technical adviser. Its primary purpose is to provide for schools, technical colleges and other training establishments a comprehensive half-hour lecture on the subject of gears. It first deals with the main functions of gears and gearing design and then describes the main techniques of cutting and generating gear teeth. The research work in connection with gear lubrication is described and particulars of investigations to ascertain the causes and cures for noise and vibration in gearing are accompanied by notes on the problems encountered in meeting the demand for increasing loads and speeds with gearing. The film is available in the standard 35mm and 16mm sizes from the Lubricants Division, Shell-Mex and B.P., Ltd., Shell-Mex House, Strand, London, W.C.2.

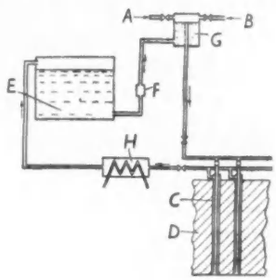
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

NUCLEAR REACTIONS

803,701. August 11, 1955.—NUCLEAR REACTORS, C. A. Parsons and Co., Ltd., Heaton Works, Newcastle upon Tyne 6. (*Inventors: Andrew Thompson Bowden and Ernest Smart.*)

The invention relates to the controlling of nuclear reactors, starting up and shutting down, varying output and adjusting neutron flux distribution within a reactor core, that part of the reactor containing the nuclear fuel. At the present time it is customary to provide such control by two separate means. The object of the invention is to provide means for controlling, whereby previous disadvantages are substantially overcome and if desired a single system can be made to perform both functions. The drawing



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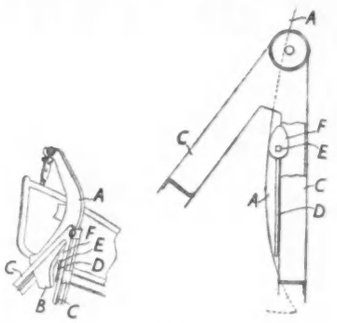
shows an embodiment of the invention wherein the control means provided are for varying the chemical composition of the neutron absorbing fluid. A neutron absorbing fluid in the form of a mixture of two components is supplied as described below, the two components being indicated at entry to the apparatus by the letters *A* and *B* to a tube *C* which is one of a series disposed within a core *D* of a reactor, that is to say the part of the reaction which contains the nuclear fuel, so that the fluid fills the tube for its full length within the core. The fluid is supplied from a main reservoir *E* by a pump *F* to a constant head mixing tank *G*. In the mixing tank constituent *A* or *B* can be added as desired to vary the composition of the fluid entering tubes *C*. The fluid leaving tank *G* enters re-entrant tubes flowing down the inner tube and then upwards between the inner and outer tube. The fluid leaving the reactor is cooled in a cooler *H* before being returned to the reservoir *E*. A suitable fluid is, for example, an aqueous solution of a water soluble cadmium salt but any sufficiently neutron absorbing fluid the absorbing properties of which can be varied by variation of chemical composition can be used, provided it does not seriously deteriorate during service in the core of the reactor.—*October* 29, 1958.

MARINE ENGINEERING

803,594. February 22, 1956.—GRAVITY DAVITS, Marine and Allied Industries (C and I), Ltd., 5, Rumford Place, Liverpool, 3, and William Cameron Rouse, 6, Granville Road, Birkdale, Lancaster.

According to the invention there is provided a gravity ship's lifeboat davit incorporating means whereby additional force can be applied to the davit arm to encourage it in its outboard movement under the action of gravity. Referring to the drawing, the davit arm *A* is shaped as shown and has a single pivot at its lower extremity or heel, a part of which is shown at *B*, by which it is pivoted to the triangular stand *C*. It will be noted that the lower part *B* of the davit arm is located within the members forming the stand *C* so that they provide good lateral support for the arm. In the fully inboard position the davit arm nests within the vertical channel member forming the rear of the stand. For the purpose of the invention a hand lever *D* is pivoted to the stand *C* as indicated at *E*. This hand lever has a cam part *F* which acts on the rear of the davit arm *A*. By turning the lever in the anti-clockwise direction a force can be applied to the rear of the davit arm to assist it or start it in its outboard movement. An extension piece may be provided for fitting to the lever *D* to provide increased leverage. If desired the hand levers of the two davits between which the boat is supported may be coupled together by a connecting rod to enable one man to control and operate both davits. In some cases the davit arms may be pivoted on simple brackets secured, for example, to the side of a deck house. The pulley wheels for the falls may be on brackets or stands on the roof of the deck house and a bulkhead top may provide a stop for halting the arm at the fully outboard position. The cam *F* or its equivalent may be operated through gearing or by a screw-jack arrangement so as to



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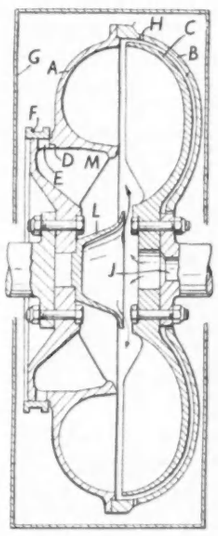
provide mechanical advantage. Operation of the cam, particularly if such operation is through gearing, may be effected by and simultaneously with the operation of the normal davit winch. Thus the one operating handle can perform the dual function of operating the cam and the winch. Similarly the winch-brake control handle could also operate the cam or its equivalent.—*October* 29, 1958.

POWER TRANSMISSION

803,462. July 9, 1954.—HYDRAULIC TURBO COUPLINGS, Fluidrive Patents, Ltd., Fluidrive Works, Worton Road, Isleworth, Middlesex. (*Inventor: John Bilton.*)

The invention relates to hydraulic turbo couplings, the object being to provide a coupling wherein provision is made for rapid partial emptying of the vortex circuit in the event of the load on the coupling and hence the torque transmitted and slip rising above a predetermined value. Referring to the drawing,



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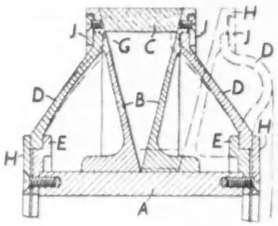
the impeller shell *A* is connected to a casing *B*, that extends over the back of the runner shell *C*, so that the working chamber is defined by the impeller shell and the casing. The back of the impeller shell is formed with an annular ledge *D* in which are formed discharge passages *E* that lead from the cavity to the exterior of the chamber. The passages *E* are uniformly spaced around the coupling axis and a valve is provided in the form of a ring *F* that is slidable axially on the ledge *D* under the action of suitable control means, so that when starting up the coupling the ring *F* can be moved to the position shown, in which it closes the passages *E* and thereby prevents the ejection of liquid from the working chamber. When the runner has attained its normal operating speed the ring *F* is moved to the left of the drawing, so as to uncover the passages in readiness for the ejection of liquid from the working chamber in the event of the torque and slip increasing, as for example when the driven member encounters an obstruction. The coupling is provided with a stationary casing *G* associated with a sump, not shown, to which fluid can flow at a restricted rate from the working chamber through the leak-off nozzles *H*, and/or the discharge passages *E*. Liquid is returned to the working circuit from pumping means within the sump through an inlet duct *J* in the output shaft. A guide ring *L* is provided to ensure that liquid delivered through the duct *J* enters the working circuit instead of passing out of the working chamber through the cavity *M* and the discharge passages *E*. Several modified forms of hydraulic turbo couplings are also shown in the specification.—*October* 29, 1958.

804,708. November 27, 1956.—ADJUSTABLE V-BELT PULLEY, Ernst Hutzenlaub, trading as the firm Wilhelm Herm. Mueller and Co., Kg., Hannover, 5, Klagesmarkt, Hanover, Germany.

Referring to the drawing, it will be seen that the adjustable V-belt pulley consists essentially of a transmission shaft *A*, two flanking V-discs *B* mounted so as to be axially displaceable on it and between which discs a V-belt *C* is arranged. Hollow rubber connecting members *D* are supported on collars *E* attached to shaft *A* and press on the discs *B*. Members *D* act,



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to a certain extent, as shock absorbers. The V-discs *B* are carried on shaft *A* as a running or sliding fit. The rubber connecting members *D* are shaped in the form of a truncated hollow cone and engage with their rims in the discs. The outer and inner rims of the connecting members *D* are firmly connected to discs *B* and collars *E*, so that they are able to transmit in a flexibly pivotable manner peripheral forces from V-belt to the shaft or vice versa. The members *D* in this manner undergo a strain on rotation, and serve at the same time to ensure the necessary pressure between discs *B* and V-belt *C*. In order to obtain the required pressure to position the belt in the pulley the connecting members *D* are axially initially tensioned. The relaxed position of the undistorted members is shown in the drawings. For the purpose of controlling the speed of rotation, one or both of the discs *B* can be moved axially, i.e. into the position *H* shown by broken lines, in which position the relevant member *D* is distorted and is bent into an approximate U-shape. The fastening of the outer and inner rims of the spring connecting members *D* may be effected by means of clamping rings *J*, which, on tightening of the associated screw coupling, grip the edges of the members *D* to lock them. Modified designs are also described in the specification.—*November* 19, 1958.

TURBO-GENERATORS

803,388. October 15, 1956.—TURBO-GENERATOR COOLING SYSTEMS, Aktiengesellschaft Brown, Boveri and Cie., Baden, Switzerland.

With turbo-generators for very high powers effective cooling is of great importance, because the power which can be produced is limited by the admissible temperature rise. The invention concerns a cooling arrangement for turbo-generators in which the rotor space is sealed in a gastight manner from the stator space and the external air. The rotor as well as the rotor winding are cooled with a gas in a closed circuit, whilst the stator winding as well as the stator laminations are cooled by a liquid in a closed circuit. In order to avoid the disadvantages of this kind of cooling arrangement, the stator space is provided with a non-combustible gas filling, such as carbon dioxide. In this way not only the disadvantages of an oil or hydrogen gas filling are avoided, but there is also the advantage that the requirements imposed on the stator casing as regards tightness are not so high as has been the case with the machines known hitherto. A further improvement can be achieved when the pressure of the non-combustible gas filling in the stator casing is regulated in dependence on the pressure of the cooling gas in the rotor space.—*October* 22, 1958.

Launches and Trial Trips

BORGNY, oil tanker; built by the Netherlands Dock and Shipbuilding Company for Fred Olsen and Co. A/S. Oslo; length overall 213·5m, breadth 28·5m, depth 14·6m, deadweight 39,000 tons, speed 17·3 knots; thirty-three cargo oil tanks, four 1250 tons per hour turbine-driven centrifugal pumps, and three 150 tons per hour stripping pumps; two 550kW, 450V, 60 c/s turbo-alternators, one 160kW diesel-driven alternator; one set of N.D.S.M.-Parsons two-stage turbines, 17,500 s.h.p. at 98 propeller r.p.m., steam supplied at 600 lb per square inch and 800 deg. Fah. by two Babcock and Wilcox boilers. Launch, August 23.

SHAFTESBURY, cargo ship; built by The Burntisland Shipbuilding Company, Ltd., for the Alexander Shipping Company, Ltd.; length between perpendiculars 430ft, breadth moulded 61ft 9in, depth moulded to upper deck 38ft 3in, draught 28ft 10½in, deadweight 11,900 tons; five holds, six 12½-ton, eight 5-ton and two 2-ton derricks; three 200kW diesel-driven generators; Hawthorn Leslie-Doxford oil engine, 5500 b.h.p. at 115 r.p.m. Trial, September.

BLUE CRUSADER, trawler; built by John Lewis and Sons, Ltd., for the Crusader Fishing Company, Ltd.; length overall 133ft, breadth 25ft 6in, depth moulded 12ft 9in, gross tonnage 274; fishroom 6500 cubic feet, electric trawl winch 150 b.h.p., 800 fathoms of 2¾in warp, one 125kW diesel-driven trawl winch generator, two 20kW diesel-driven generators; Widdop mark G.M.B.7 diesel engine 640 b.h.p. at 250 r.p.m. Trial, September 3.

WIMBLEDON, cargo liner; built by Barclay, Curle and Co., Ltd., for the Britain Steamship Company, Ltd.; length overall 487ft, breadth 63ft, depth to bridge deck 47ft, gross tonnage 9300; five main cargo holds, two 20-ton derricks, 10-ton derricks at cargo holds, 3-ton derricks and deep tanks, electric winches; two 290kW diesel-driven generators, one 300kW gas turbine-driven generator; Barclay, Curle-Doxford oil engine, six cylinders 670mm diameter by 2320mm combined stroke, Bibby detuner flywheel, arranged to burn heavy fuel. Trial, September 8.

Catalogues and Brochures

LONDEX, Ltd., 207, Anerley Road, London, S.E.20.—Leaflet describing smoke alarm and density units.

THE CAPE ASBESTOS COMPANY, Ltd., 114 and 116, Park Street, London, W.1.—Technical data sheet describing "Caposite" asbestos insulation.

W. H. MARLEY AND CO., Ltd., New Southgate Works, 105, High Road, London, N.11.—Illustrated leaflet describing keyway broaching equipment.

RANSOMES AND RAPIER, Ltd., Waterside Works, Ipswich.—Leaflets dealing with high discharge truck mixers and agitators; tilting agitators; and horizontal drum truck mixers and agitators.

DALLOW LAMBERT AND CO., Ltd., Thurmaston, Leicester.—Illustrated folder containing a selection of photographs giving a general indication of applications of the company's equipment for dust control.

FIRTH CLEVELAND STEEL STRIP, Ltd., 299, Oxford Street, London, W.1.—Illustrated brochure giving details of the cold rolled steel strip and flattened wire recently introduced under the trade mark "Fircleve."

BRITISH RESIN PRODUCTS, Ltd., Devonshire House, Piccadilly, London, W.1.—Technical booklet containing details and illustrations of section dimensions, together with weights and methods of fabrication of "Rockite" rigid extrusions.

RADIOVISOR PARENT, Ltd., Stanhope Works, High Path, London, S.W.19.—Illustrated brochure describing the facilities available in the Radiovisor organisation for the production of flame failure protection and automatic control equipment.

DANIEL DONCASTER AND SONS, Ltd., Penistone Road, Sheffield.—Booklet entitled "The Manipulation of Difficult Wrought Materials," describing and illustrating the resources available for the working of titanium, Nimonic, aluminium bronze, heat-resisting alloys, &c.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Dec. 12.—STOKE AND CREWE BRANCH: Royal Hotel, Crewe, "Fuel Efficiency," H. B. Weston, 7.30 p.m.

Tues., Dec. 16.—ALDERSHOT AND DISTRICTS BRANCH: Red Cross Hall, High Street, Aldershot, "Relays and Automatic Control in Engineering," W. L. Stern, 7.30 p.m. ★ TYNESIDE BRANCH: Crown Hotel, Newcastle, "Heat Treatment and Hardening," 7.30 p.m.

Wed., Dec. 17.—WOLVERHAMPTON AND DISTRICT BRANCH: Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, "Power Factor Current Equipment," R. S. Stevens, 7.45 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Dec. 12.—LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Technical Films, 6.30 p.m.

Wed., Dec. 17.—LONDON BRANCH: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "A Vidicon Camera for Industrial Colour Television," I. J. P. James, 6.30 p.m.

Thurs., Dec. 18.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Design and Construction of Precision Toroidal Potentiometers for Data Transmission," H. J. Arnott, 7 p.m.

Fri., Dec. 19.—SCOTTISH SECTION: Department of Natural Philosophy, The University, Drummond Street, Edinburgh, "Design and Construction of Precision Toroidal Potentiometers for Data Transmission," H. J. Arnott, 7 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., Dec. 17.—NORTH WESTERN REGION: Engineers' Club, Albert Square, Manchester, "The Utilisation of Industrial Wastes as Fuel," C. E. Newman, 2.30 p.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., Dec. 18.—Institute of Marine Engineers, Memorial Building, 76, Mark Lane, London, E.C.3, "Report on Heavy Oil Engine Working Costs and Performance, 1957/58"; Discussion on "Operating Problems," and "Modern Trends in High Speed Diesel Engines," L. D. E. Brodie, 2.30 p.m.

INCORPORATED PLANT ENGINEERS

Wed., Dec. 17.—KENT BRANCH: Kings Head Hotel, High Street Rochester, "Treatment of Trade Effluents and Methods of Purification," T. Waldmeyer, 7 p.m.

Thurs., Dec. 18.—BLACKBURN BRANCH: White Bull Hotel, Blackburn, "About Windmills," Rex Wailes, 7.30 p.m. ★ MERSEYSIDE AND NORTH WALES BRANCH: The Blossoms, Chester, Films, "Corrosion in Action" and "Le Mans Race," 7.15 p.m.

INDUSTRIAL WELFARE SOCIETY

Mon. and Tues., Dec. 15 *and* 16.—Robert Hyde House, 48, Bryanston Square, London, W.1, Two-Day Course on "Wage Administration and Incentives," 10 a.m. to 5 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Dec. 16.—EAST ANGLIAN SECTION: Lecture Hall, Public Library, Ipswich, Three Talks on "Sand Casting, Die-Casting and Metallurgy of Aluminium Alloys," 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Dec. 15.—WEST OF ENGLAND SECTION: Grand Hotel, Bristol, Films on "The Formation, Location and Methods of Drilling and Obtaining Oil from the Earth," 7.30 p.m.

Thurs., Dec. 18.—NORTH EAST COAST SECTION: Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne, "Welding in Marine Engineering," J. A. Dorrat, 6.15 p.m.

INSTITUTE OF NAVIGATION

Fri., Dec. 19.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Admiralty Chart," G. S. Ritchie and A. J. R. Tyrell, 5.15 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, Dec. 12.—SOUTH WALES CENTRE: South Wales Institute of Engineers, Park Place, Cardiff, "Costs and Costing Relating to the Operation and Maintenance of a Fleet of Vehicles," W. J. Edbrooke, 7 p.m.

Mon., Dec. 15.—EAST REGIONAL CENTRE: Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, "Fibre Glass and its Uses," 7.30 p.m.

Tues., Dec. 16.—WEST REGIONAL CENTRE: Liverpool Architectural Society's Rooms, Bluecoat Chambers, School Lane, Liverpool, 1, "From the Laboratory to the Road," D. W. Bravey, 7.30 p.m.

Thurs., Dec. 18.—METROPOLITAN AREA: Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "Transport Developments in U.S.A.," J. F. Moon, 6.30 p.m. ★ YORKSHIRE CENTRE: Great Northern Hotel, Wellington Street, Leeds, 1, "Molybdenum Disulphide," P. Kettlewell, 7.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Mon., Dec. 15.—NORTHERN CENTRE: North Eastern Board's Lecture Theatre, Carliol House, Newcastle upon Tyne, "Farm Machinery in the U.S.A.," H. T. Horsman, 6.45 p.m. ★ WESTERN CENTRE: Royal Agricultural College, Cirencester, "Hydraulics in Agriculture," 7.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Dec. 17.—Geological Society, Burlington House, Piccadilly, London, W.1, "Liquid Distribution in Grid Packings—Part 1: The Mechanism of Liquid Spread; Part 2: Evaluation of Packing Constants," J. W. Mullin, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Dec. 16.—Great George Street, Westminster, London, S.W.1, "Hamilton Falls Hydro-Electric Scheme," E. N. Webb, 5.30 p.m.

Sat., Dec. 20.—NORTH WESTERN ASSOCIATION: Queen Hotel, Chester, Conversazione, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Dec. 12.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "The Teaching of Mathematics to Engineers," opened by M. Bridger, 6 p.m. ★ EAST MIDLAND CENTRE: Technical College, The Newarkes, Leicester, "The National-Elliott 405 Computer and its Application to Production Procedures," H. A. Mathews, 7.15 p.m. ★ NORTH SCOTLAND SUB-CENTRE: Robert Gordon's Technical College, Aberdeen, "Electrical Installation at Calder Hall Nuclear Power Station," N. J. Mackay and E. Hardwick, 7.30 p.m. ★ SOUTHERN CENTRE: S.E.B. Showrooms, Newport, Isle of Wight, Open Discussion, 6.30 p.m.

Mon., Dec. 15.—RADIO AND TELECOMMUNICATIONS SECTION: Savoy Place, London, W.C.2, "The Acoustic Design of Talks Studios and Listening Rooms," C. L. S. Gilford, 5.30 p.m. ★ MERSEY AND N. WALES CENTRE: Town Hall, Chester, "Electricity in Modern Commercial Horticulture," C. A. Cameron Brown and A. W. Gray, 6.30 p.m. ★ N.E. RADIO AND MEASUREMENT GROUP: King's College, Newcastle upon Tyne, "Magnetic Tape for Data Recording," C. D. Mee, 6.15 p.m. ★ SHEFFIELD SUB-CENTRE: Angel Hotel, Brigg, Discussion on "Electrical Maintenance Problems in Factory and Supply Systems," 6.45 p.m. ★ N. STAFFORDSHIRE SUB-CENTRE: Technical College, Stafford, "The Use of Steel-Tank Mercury-Arc Inverters for Generating Medium Frequencies for Induction Heating," D. L. Smart, 7 p.m.

Tues., Dec. 16.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, Discussion on "Modern Control Techniques on the Railways," opened by W. J. Webb and L. A. Ginger, 5.30 p.m. ★ S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "Standardization of Control Facilities for the British Grid: Communications, Indications and Telemetering," P. F. Gunning; "The Development of Communication, Indication and Telemetering Equipment for the British Grid," G. A. Burns, F. Fletcher, C. H. Chambers and P. F. Gunning, 7 p.m.

Wed., Dec. 17.—SUPPLY SECTION: Savoy Place, London, W.C.2, "The Design and Performance of the Gas-Filled Cable System," E. P. G. Thornton and D. H. Booth, 5.30 p.m. ★ SHEFFIELD SUB-CENTRE: Grand Hotel, Sheffield, "A New Cathode-Ray Tube for Monochrome and Colour Television," D. Gabor, P. R. Stuart and P. G. Kalman, 6.30 p.m. ★ S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Standardization of Control Facilities for the British Grid: Communications, Indications and Telemetering," P. F. Gunning; "The Development of Communication, Indication and Telemetering Equipment for the British Grid," G. A. Burns, F. Fletcher, C. H. Chambers and P. F. Gunning, 7 p.m.

Tues., Dec. 23.—S.W. SUB-CENTRE: St. Luke's College, Exeter, Christmas Holiday Lecture for Schoolchildren, "Electric Motors and the Electrical Industry," G. H. Rawcliffe, 2.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Dec. 16.—39, Elmbank Crescent, Glasgow, "Applications of Digital Computers," D. C. Gilles, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Dec. 12.—STEAM GROUP DISCUSSION: 1, Birdcage Walk, Westminster, London, S.W.1, "Boiler and Component Troubles," 6 p.m.

Mon., Dec. 15.—DERBY A.D. CENTRE: Midland Hotel, Derby, "Years of Development," R. A. Wilson-Jones, 7.15 p.m. ★ SCOTTISH A.D. CENTRE: Institution of Engineers and Shipbuilders, Glasgow, Technical Film Show, 7.30 p.m. ★ MIDLAND GRADUATES' SECTION: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Industrial Hydraulics," A. C. M. Sigsworth, 7 p.m.

Tues., Dec. 16.—LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "Work Study," G. W. Thornton, 6.30 p.m.

Wed., Dec. 17.—LUBRICATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Soluble Cutting Oils in General Engineering Workshop Practice," 6 p.m. ★ NORTH EASTERN A.D. CENTRE: New Chemistry Theatre, The University, Leeds, "Air Suspension for Road Vehicles," J. H. Sainsbury, 7.30 p.m.

Thurs., Dec. 18.—LONDON GRADUATES' SECTION: Visit to Daily News, Ltd., Bouverie Street, London, 9.15 p.m.

Fri., Dec. 19.—JAMES CLAYTON LECTURE: 1, Birdcage Walk, Westminster, London, S.W.1, "The Hydraulic Turbine in Evolution," P. Danel, 6 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Dec. 18.—Geological Society, Burlington House, Piccadilly, London, W.1, "Adsorption Kinetics Applied to Flotation," H. Marchandise, and "Structure and Economic Mineralization of the Silvermines District, County Tipperary, Eire," H. N. Rhoden, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Dec. 12.—NEWCASTLE UPON TYNE SECTION: Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, Film evening, 7 p.m.

Wed., Dec. 17.—SCOTTISH REGION: North British Hotel, Princes Street, Edinburgh, "Gear Production," W. H. Harrison, 7.30 p.m.

Thurs., Dec. 18.—SCOTTISH REGION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Machine Tool Development in U.S.S.R.," N. Stubbs, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Dec. 12.—WALES AND MONMOUTHSHIRE BRANCH: S. Wales Institute of Engineers, Park Place, Cardiff, Symposium of papers on "The Education and Training of a Civil Engineer," B. Neal, A. Harvey and A. Borlase, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 12.—INAUGURAL MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Induction of William Milton Larke as president; Presidential Address, "Inspiration and Integration," 7.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Dec. 12.—Mining Institute, Neville Hall, Newcastle upon Tyne, "Economics of Ship Time," R. M. Thwaites, 6.15 p.m.

NEWCOMEN SOCIETY

Wed., Dec. 17.—Lecture Theatre, Science Museum, South Kensington, London, S.W.7, "Early Water Turbines in the United Kingdom," P. N. Wilson, 5.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Mon., Dec. 15.—TEES-SIDE BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, Film Show, 6 p.m.

PHYSICAL SOCIETY

Thurs. to Sat., Dec. 18 *to* 20.—Cavendish Laboratory, Cambridge, Conference on "Interfacial Phenomena."

PLASTICS INSTITUTE

Tues., Dec. 16.—Wellcome Building, 183–193, Euston Road, London, N.W.1, "Plastics in the Construction of Buildings," V. H. Wentworth, 6.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Dec. 16.—MIDLAND COUNTIES BRANCH: Birmingham and Midland Institute, Paradise Street, Birmingham, "The Design and Construction of Shell Roofed Buildings for Cadbury Bros., Ltd., at Moreton," J. E. C. Farebrother and L. E. May, 6 p.m.

Wed., Dec. 17.—11, Upper Belgrave Street, London, S.W.1, "The Articulation of Concrete Structures," Lieut.-Colonel J. F. Field-Smith, 6 p.m.

ROYAL STATISTICAL SOCIETY

Thurs., Dec. 18.—ORDINARY MEETING: London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, "The Determinants of Wage Inflation in the U.K., 1946–56," J. C. R. Dow and L. A. Dicks-Mireaux, 5.15 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Mon., Dec. 15.—The University Building, St. George's Square, Sheffield, "Continuous Casting at Barrow," I. M. D. Halliday, 7.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Thurs., Dec. 18.—ROAD AND BUILDING MATERIALS GROUP: Lecture Hall, 14, Belgrave Square, London, S.W.1, Special Meeting, "The Polishing of Roadstones," D. J. Maclean and F. A. Shergold; "An Automatic Sieving Machine," D. C. Soul; "Some Uses of Statistics in a Brickworks Laboratory," R. Richards, 2.30 p.m.; "The Determination of the Cement Content of Soil-Cement Mixtures," P. T. Sherwood; "Measurement of the Acidity of Bitumen by Potentiometric Titration," D. H. Mathews, and "Development of the Concrete Cube Test as a Measure of the Quality of Cement," E. Burke, 5.30 p.m.

Fri., Dec. 19.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, "Modern Views of Electrochemical Processes"; "Cathodic Processes," E. C. Potter, 2.30 p.m., and "Anodic Processes," T. P. Hoar, 5.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, Dec. 12.—39, Elmbank Crescent, Glasgow, C.2, "Some Experience in the Use of the Quantovac in a Steelworks Laboratory," S. Muir, 6.45 p.m.

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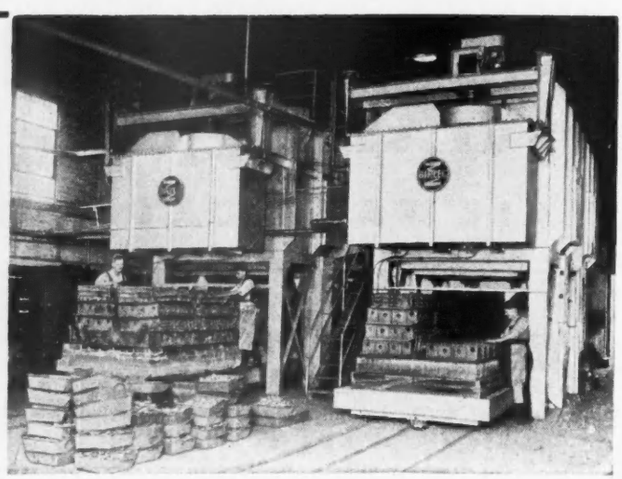

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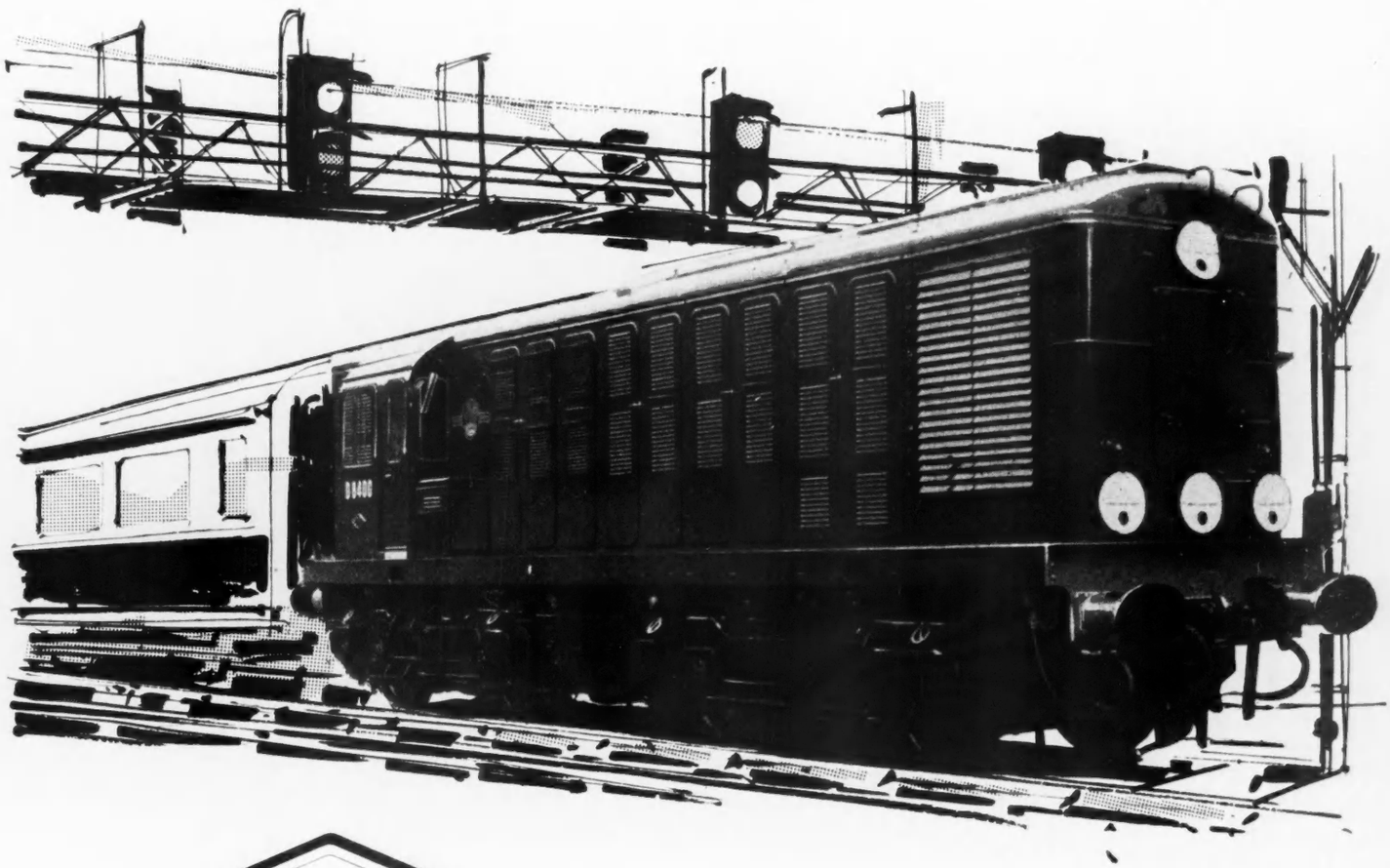

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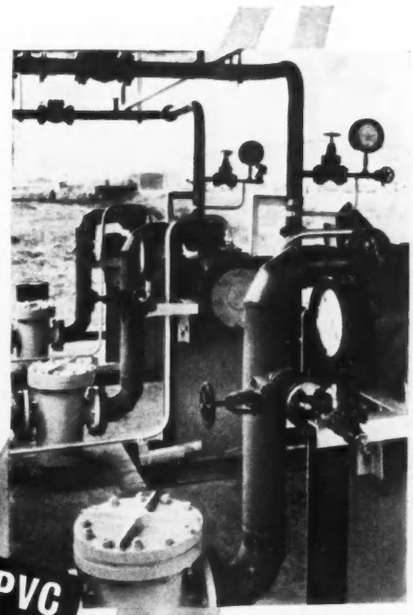

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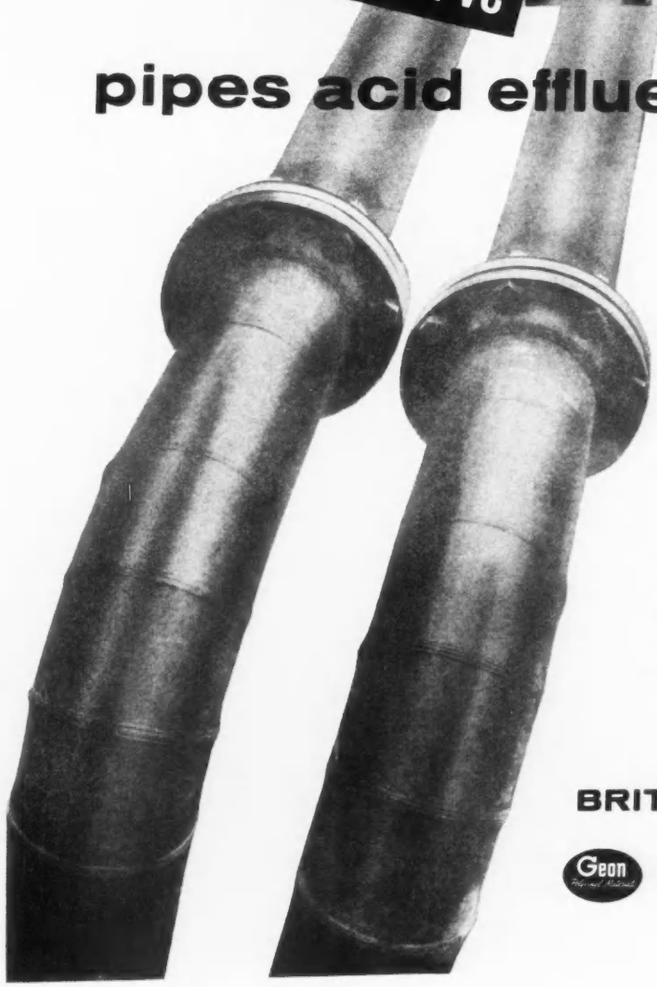

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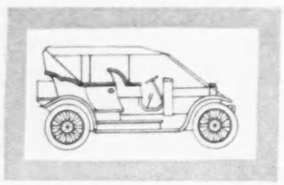

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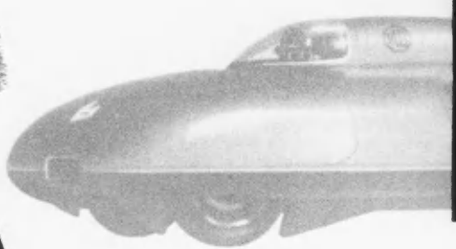

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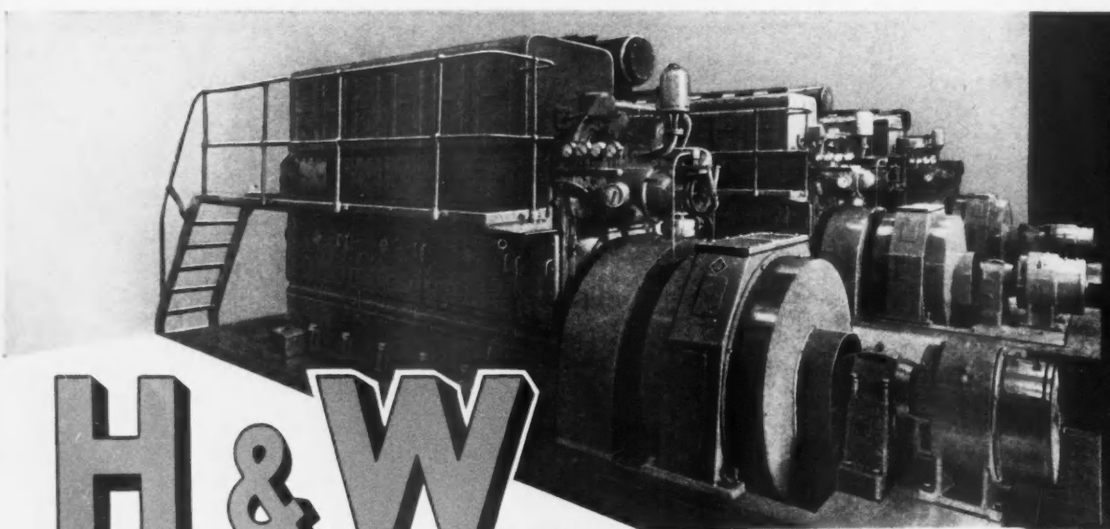

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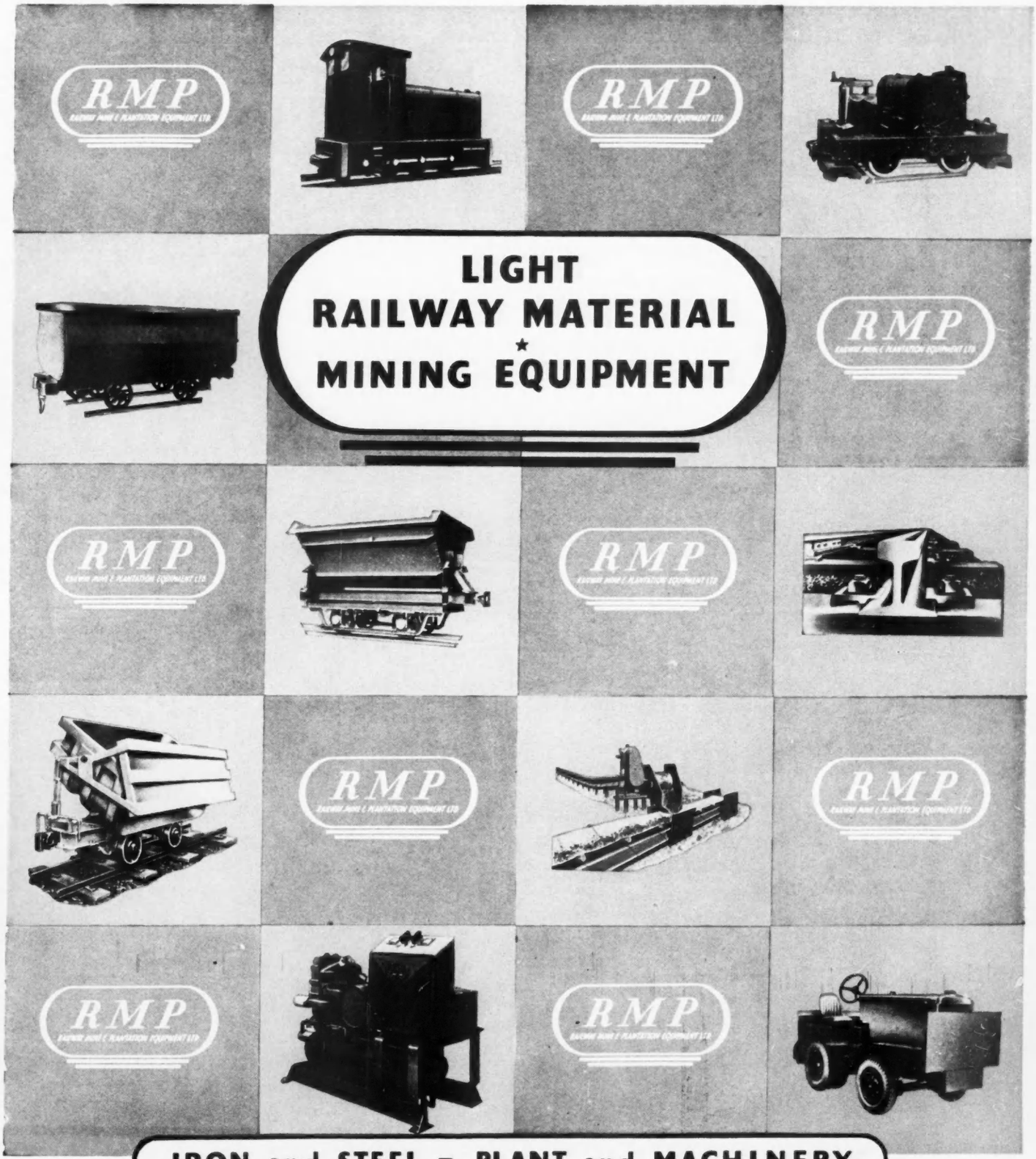

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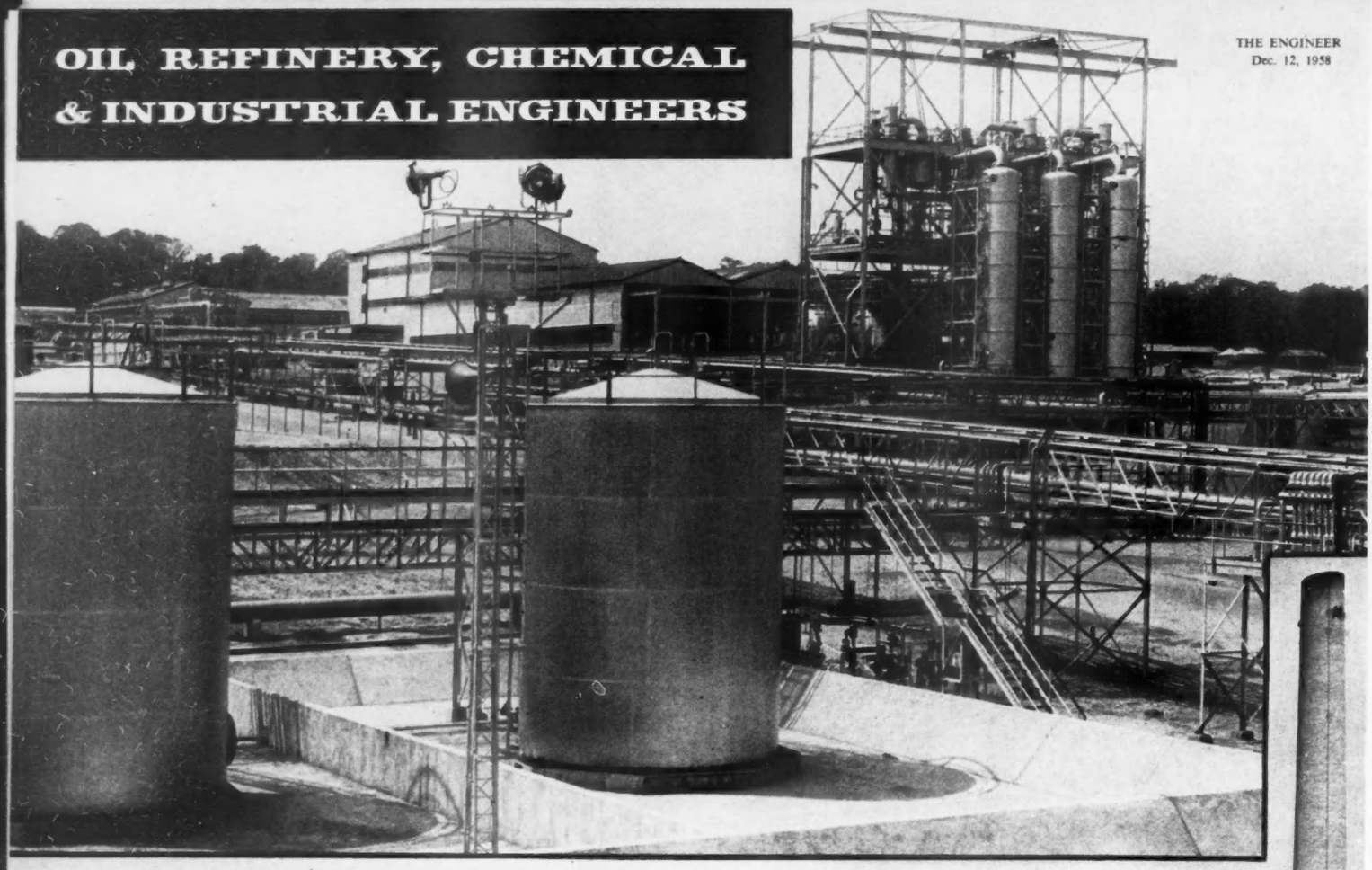

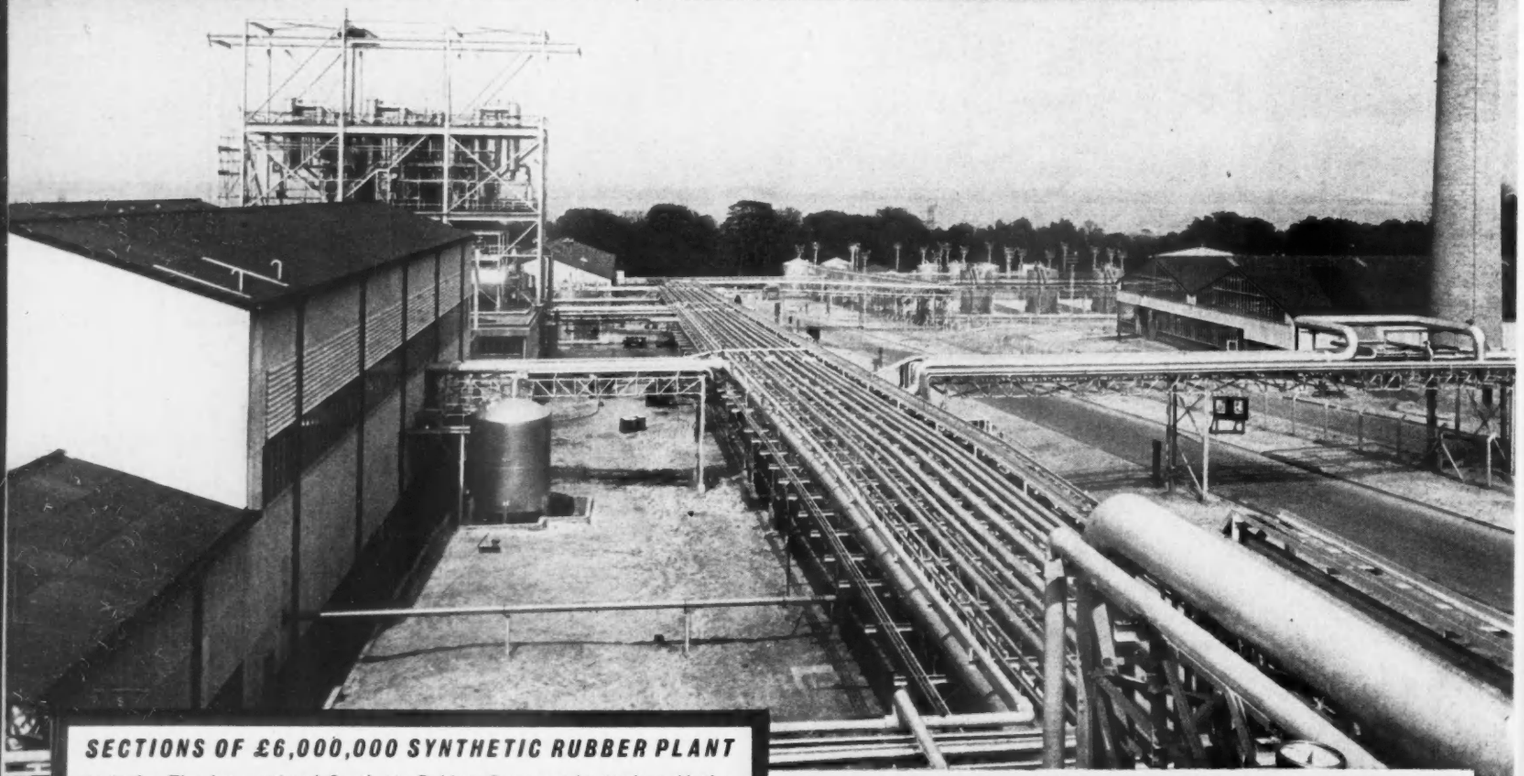

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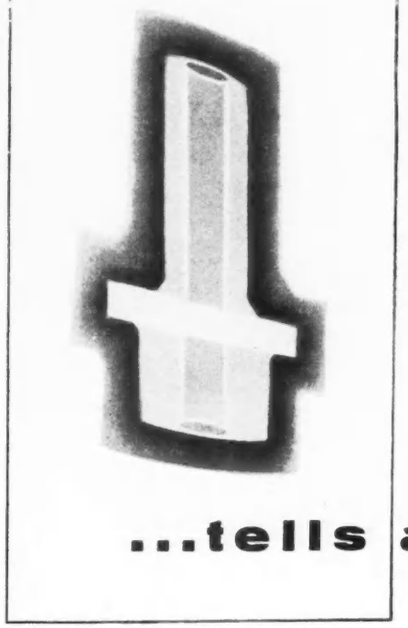

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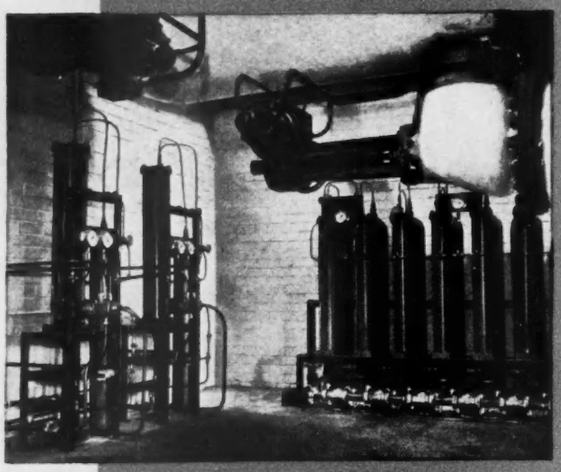

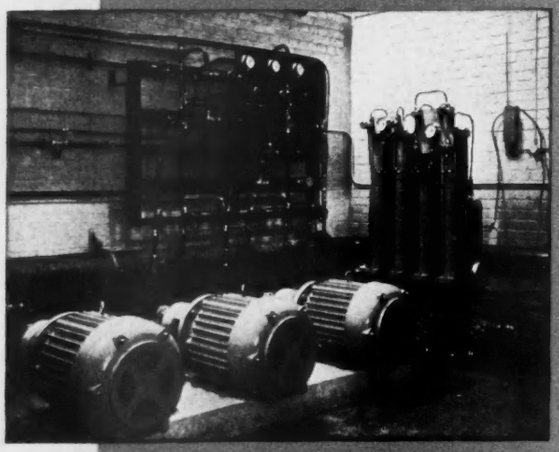

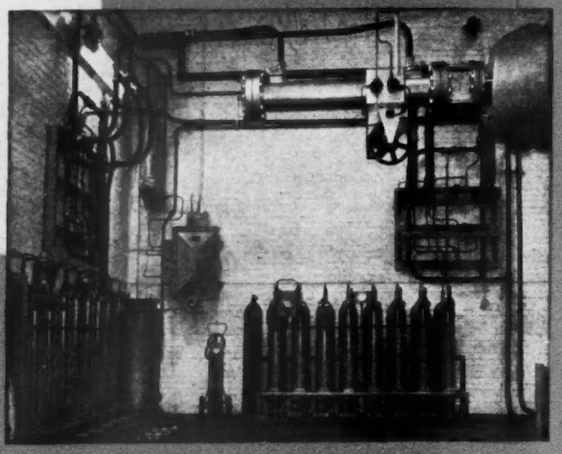

TOP RIGHT

To control the amount of air fed to the ramjet on test, Lockheed hydraulic controls, including over 40 accumulators, have been installed by Bristol Aero-Engines at their new test plant. Six large gate valves operated by 8" diameter cylinders are actuated by Lockheed finger-tip control.

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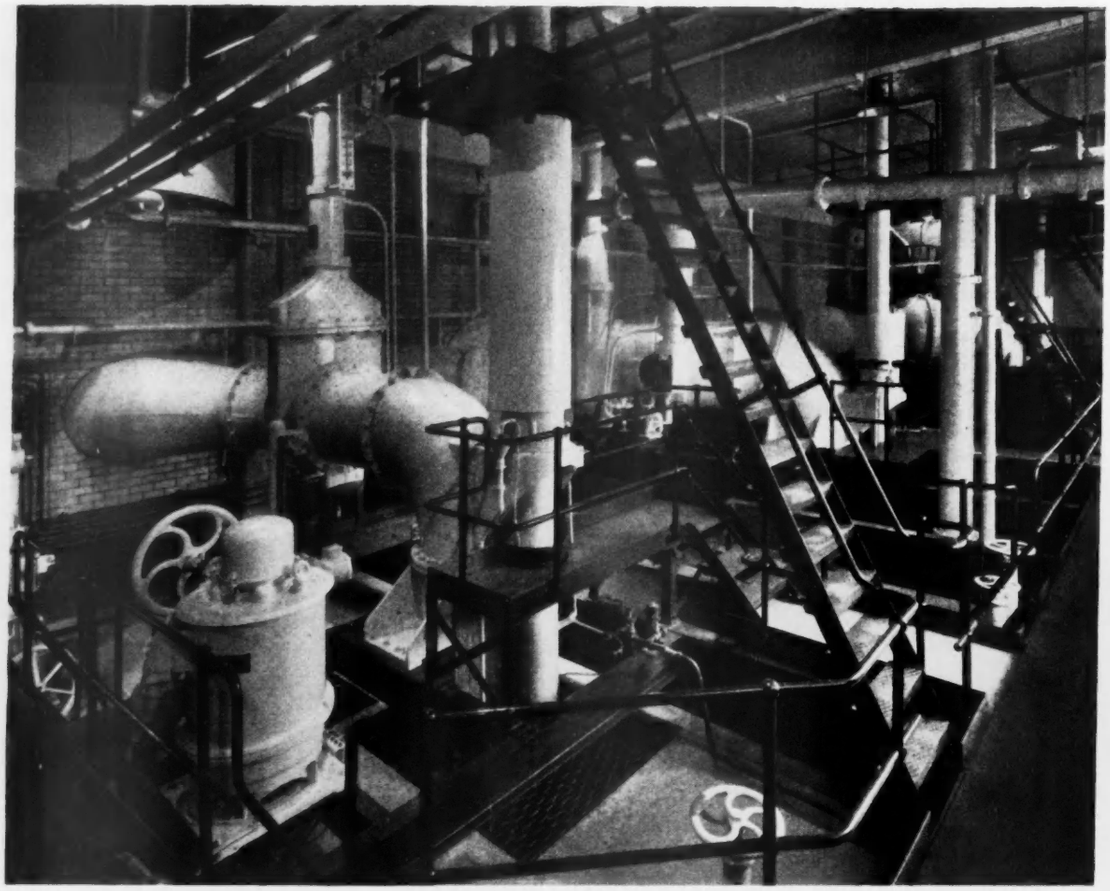
STEEL

213



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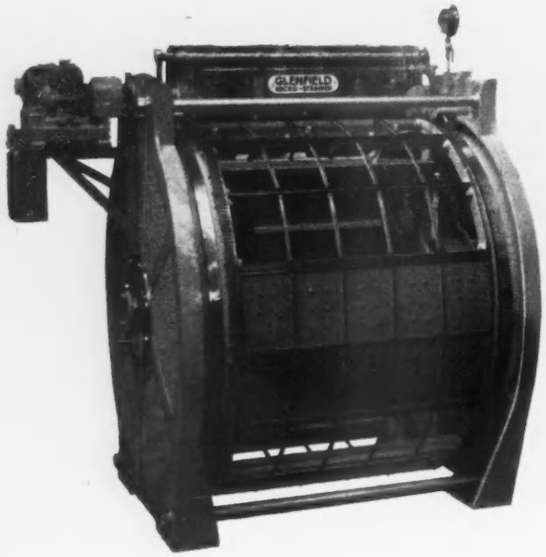

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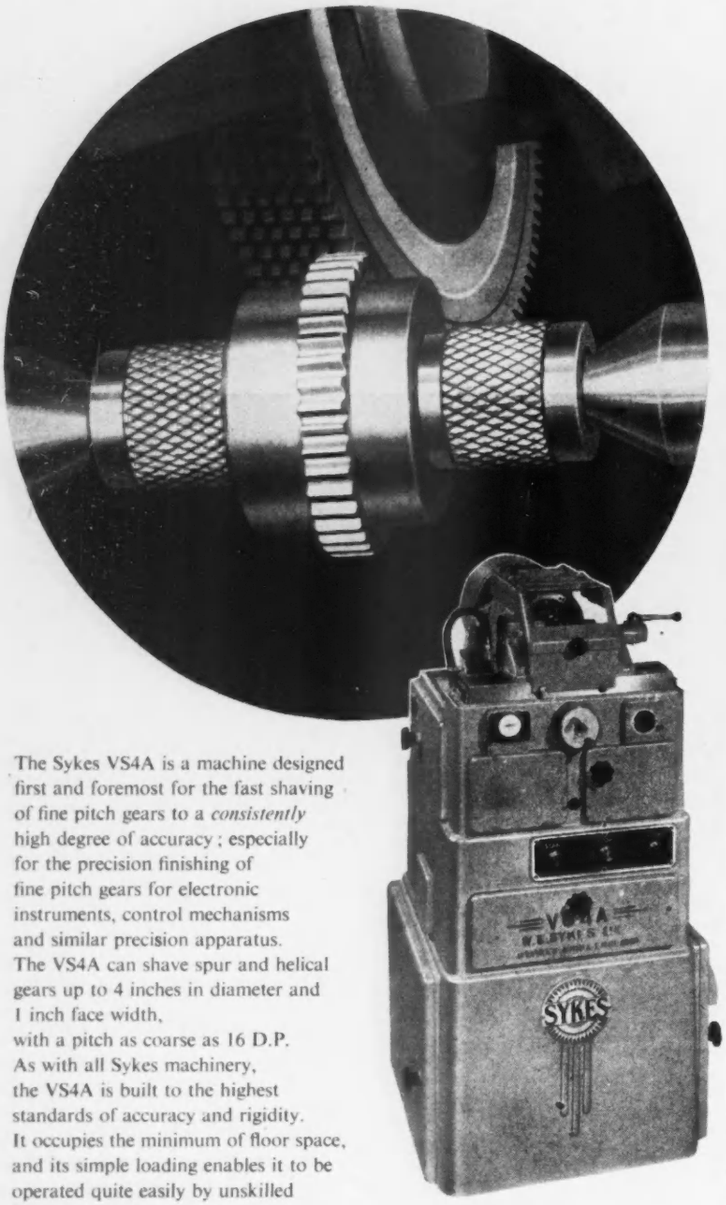

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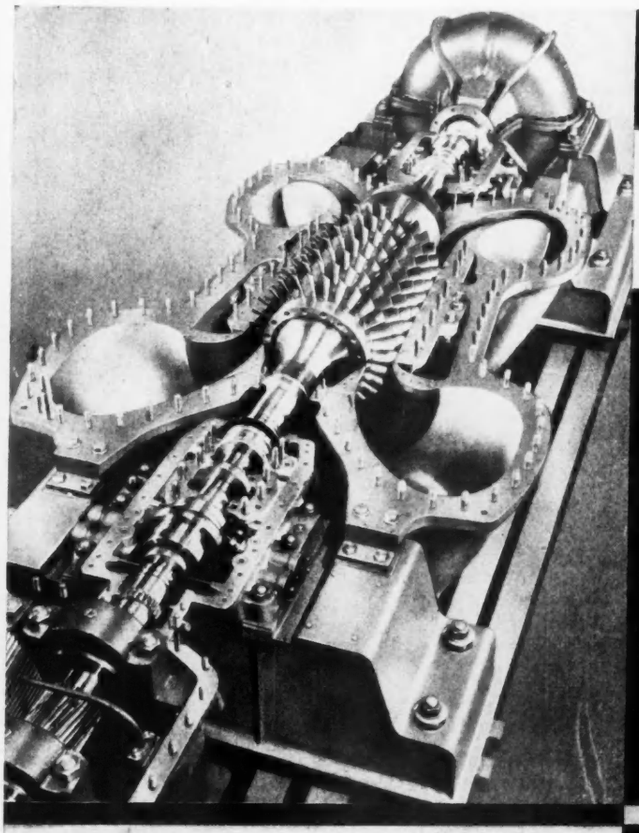

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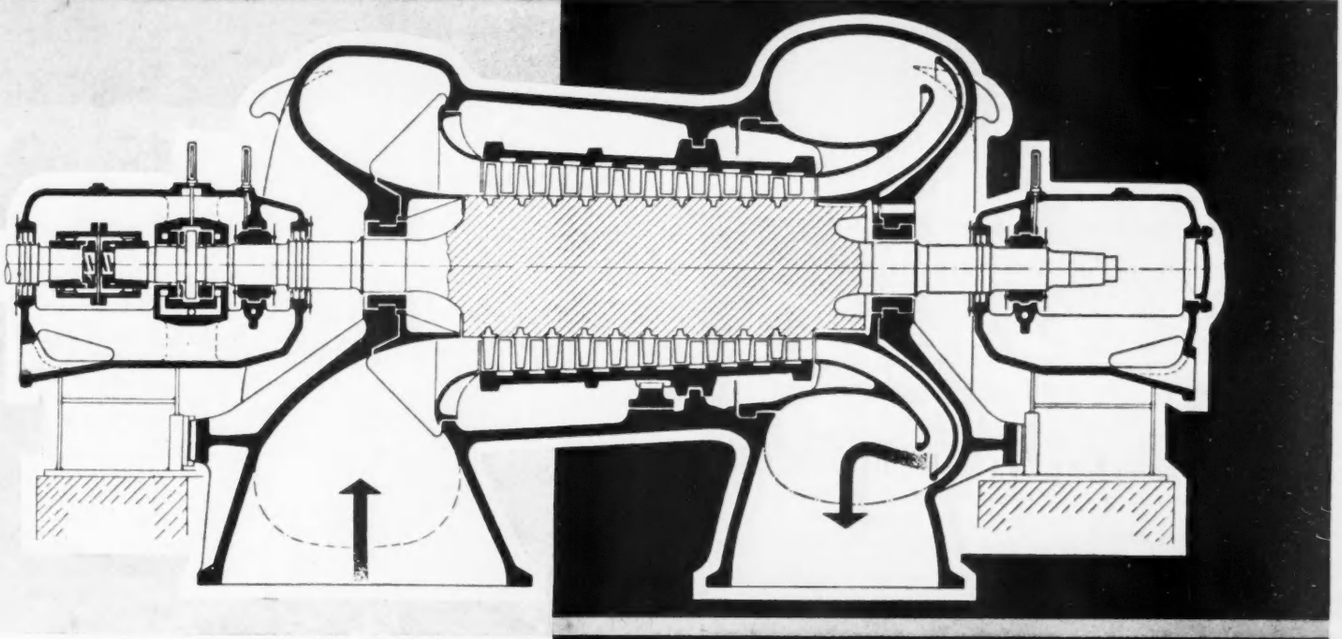

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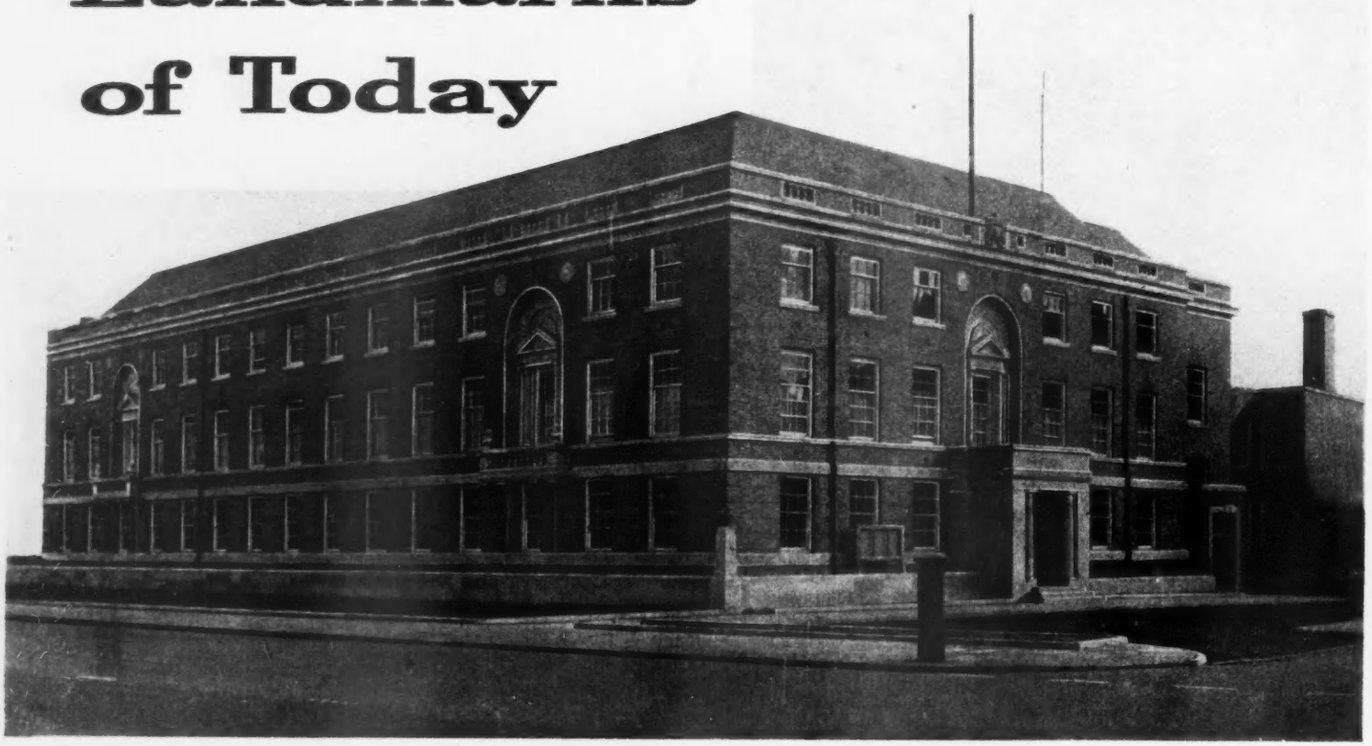

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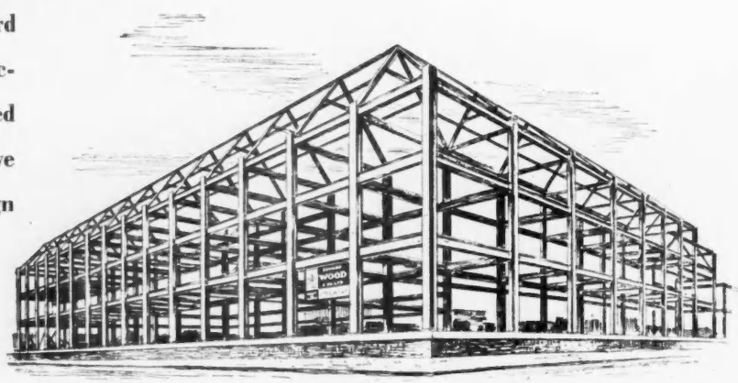

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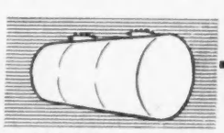

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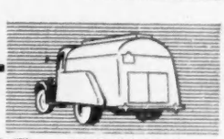

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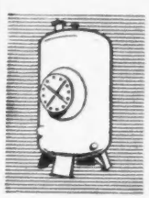

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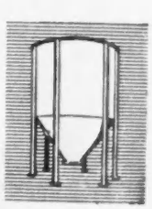

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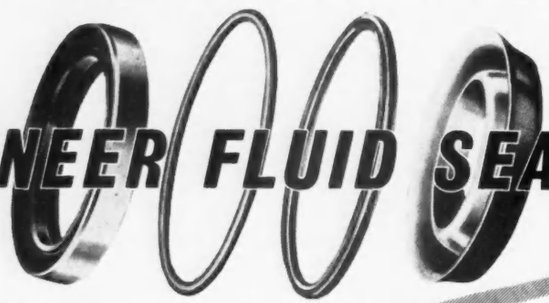

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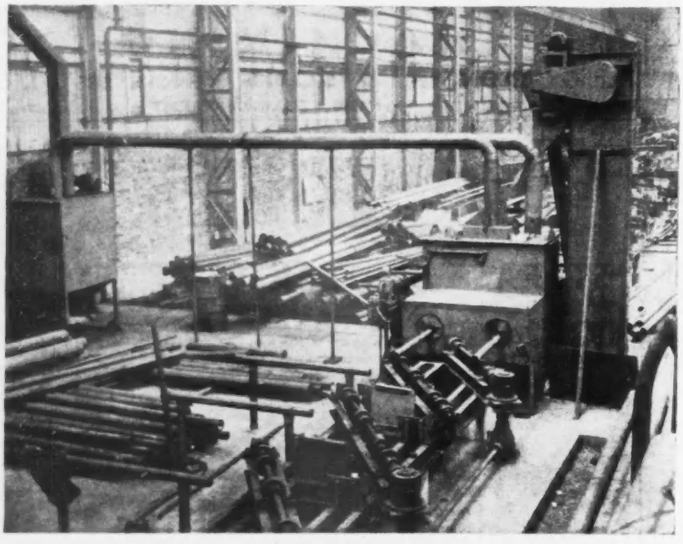

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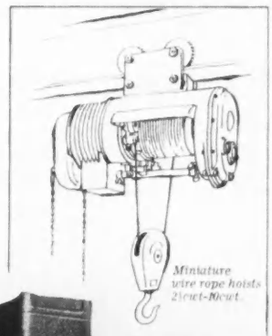
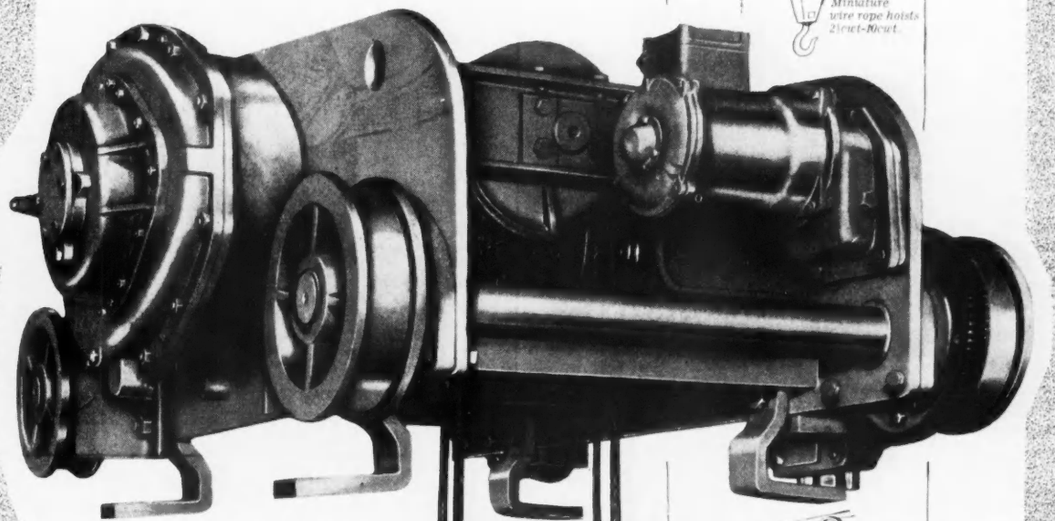


Miniature wire rope hoists 2½cwt-10cwt.



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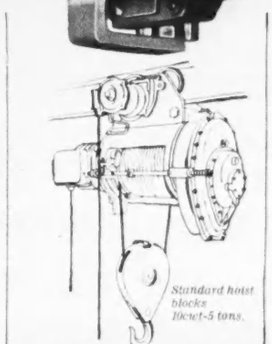

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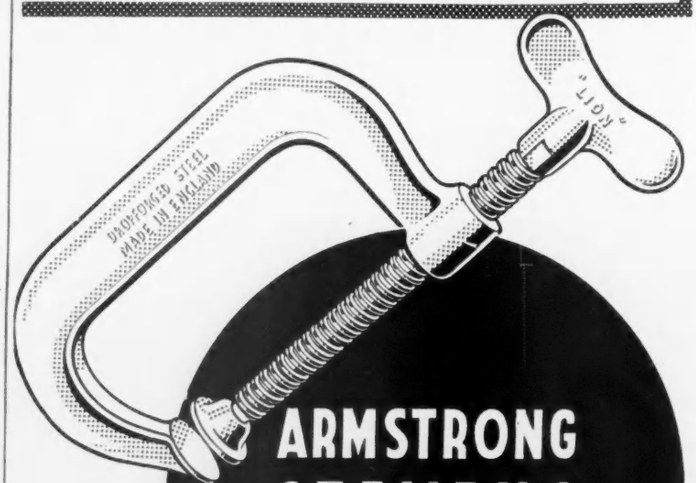

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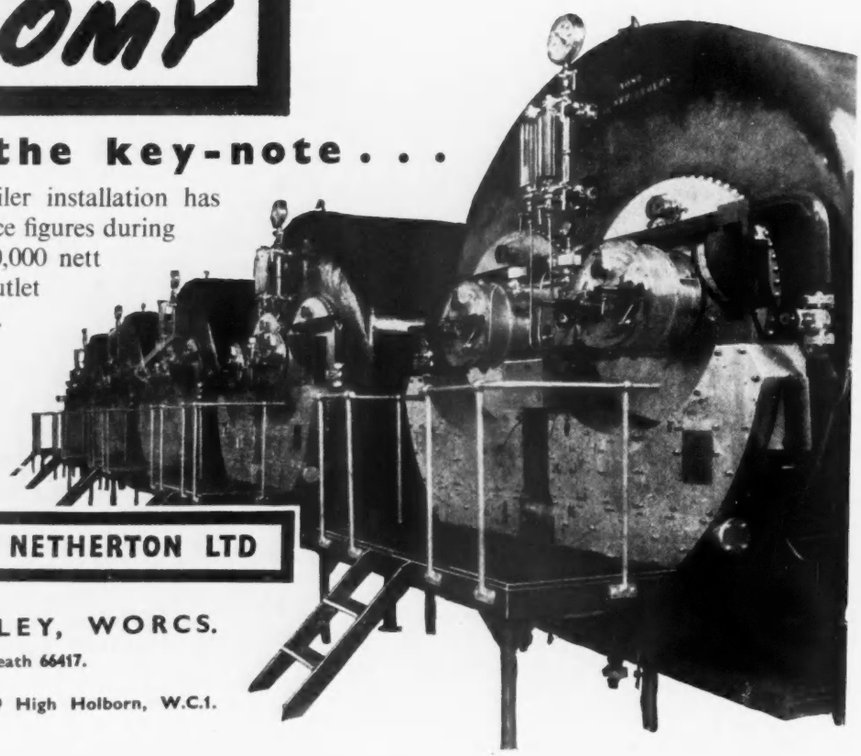
Nightingale Road Factory, Derby. Photograph by courtesy of Rolls Royce Ltd.



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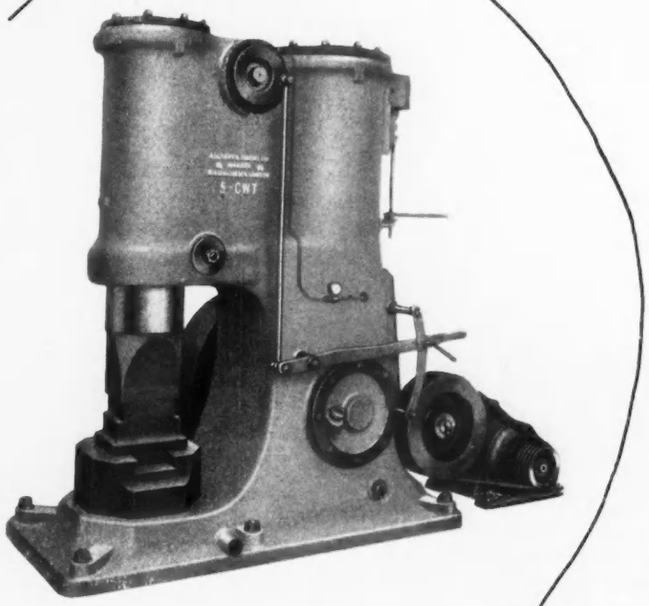

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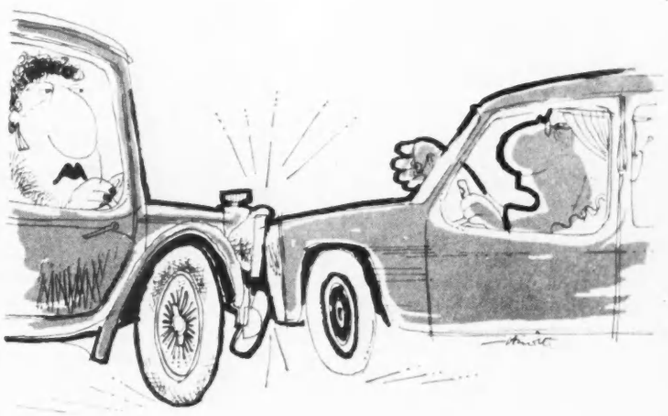
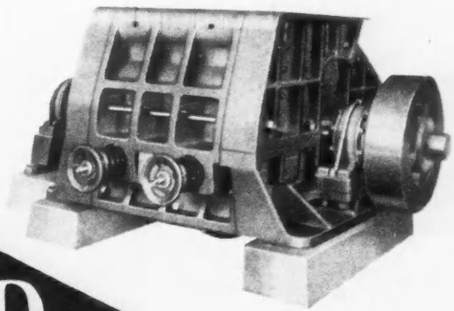
On making an impact



C-R-A-C-K! Head-on collisions produce a resounding impact, even with odd-looking cars (and drivers) such as the illustration shows. Results are startling and often disastrous. On the other hand, using *controlled* impact as a means of reducing industrial materials, B.J-D Crushers give highly satisfactory products. Materials fed into the crusher are subjected to blows from hammers attached to a revolving rotor. In the case of the FLEXTOOTH Crusher, shown below, the hammers swing as they rotate so that the blows are particularly sharp and telling. There are many other types of crusher in the B.J-D range, each securing optimum results on particular applications.



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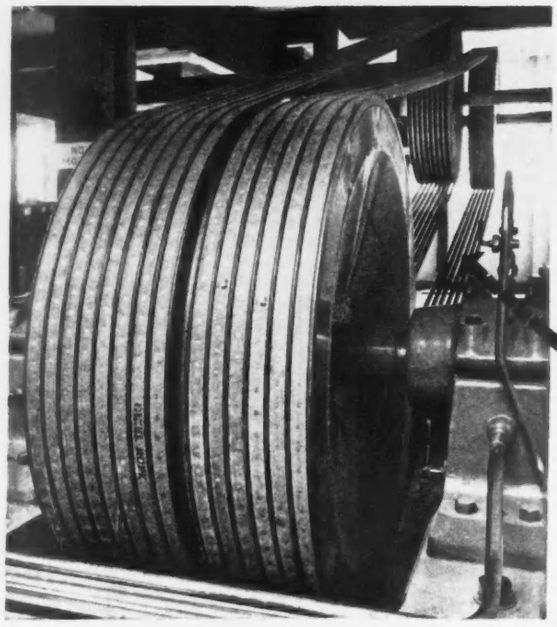

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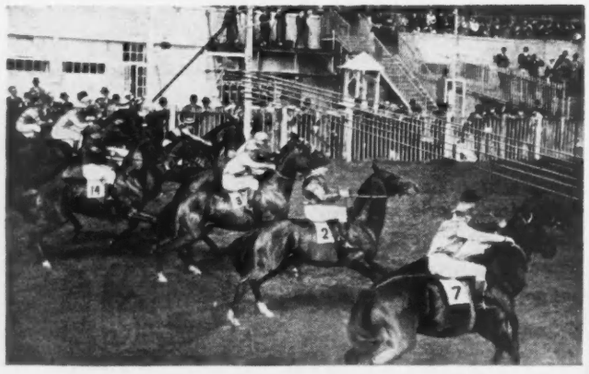
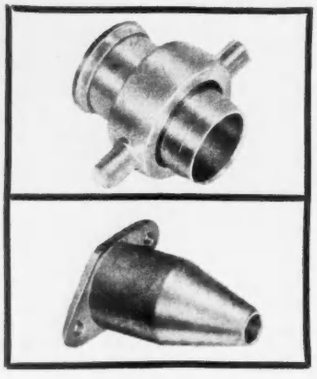


The choice is often difficult



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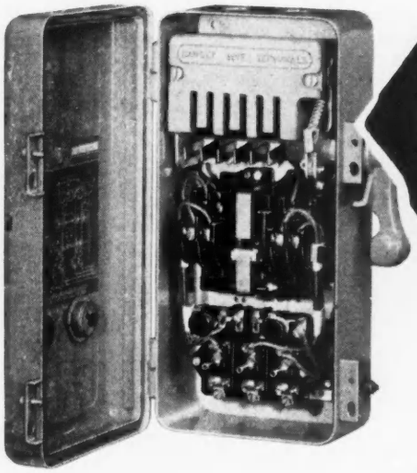
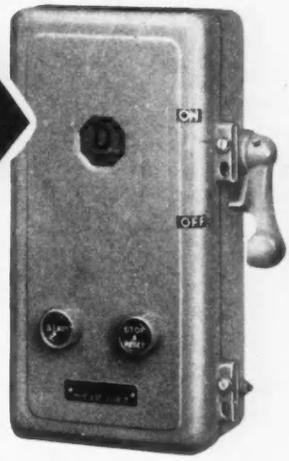


INSIDE and OUTSIDE



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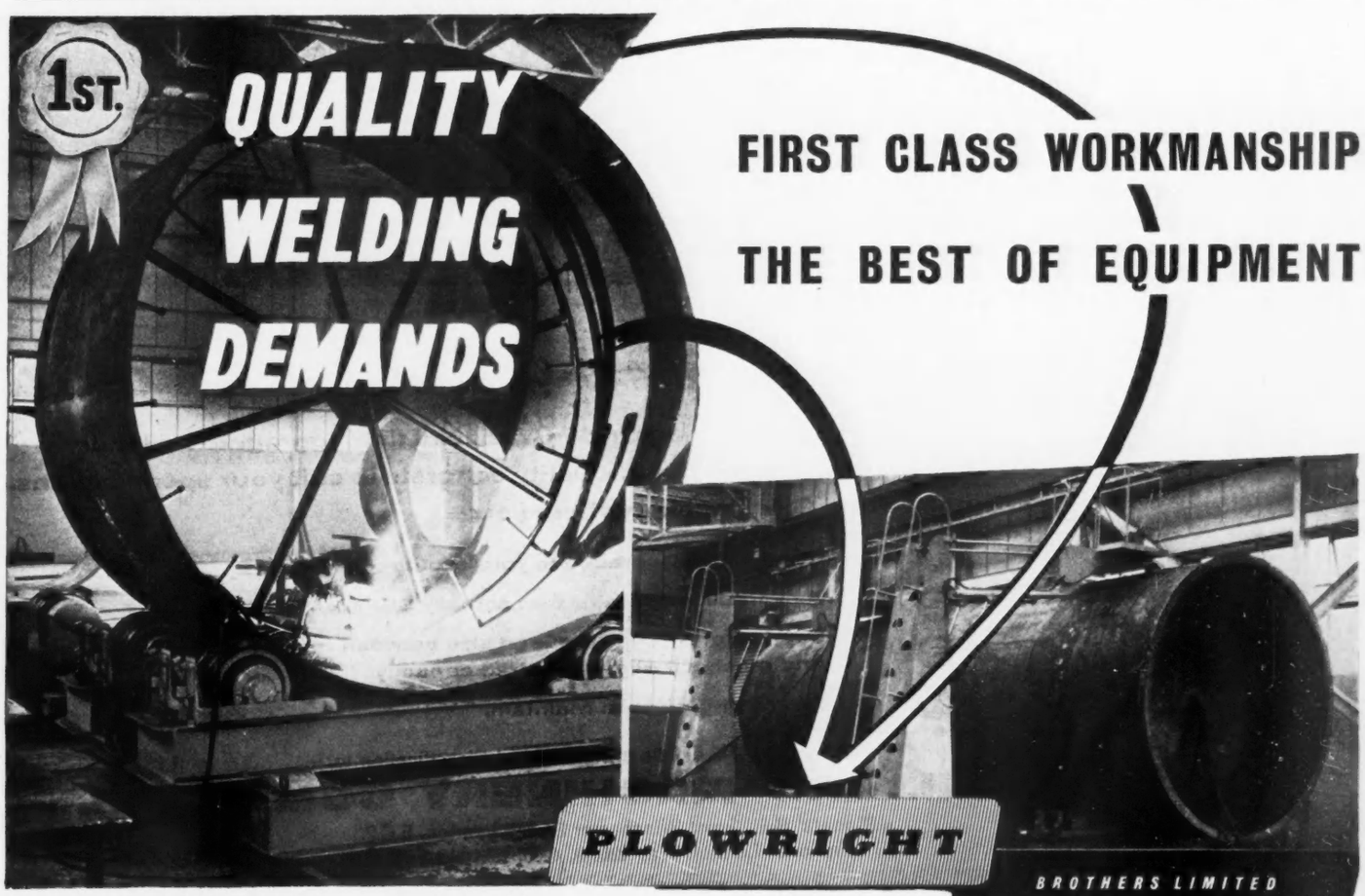

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THE FINANCIAL TIMES WEDNESDAY SEPTEMBER 17 1958

Rapid Progress at Kariba

By Our Rhodesian Correspondent

Half the main wall of the Kariba Dam is now in place. Every month another 90,000 cubic yards of concrete are poured between steel shuttering rigged on the rising crests of the 42 blocks curving across the Zambesi.

Cables span the river, supporting three Blondin buckets which shuttle back and forth, bringing 20 t... The buckets are "talked down" to... operators using portable radio-telephone sets. The construction programme has been accelerated, following the unprecedented flood last February.

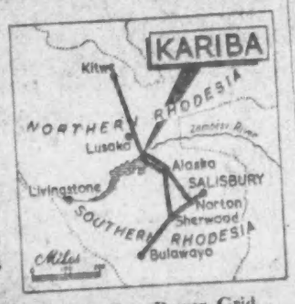
The four gaps left in the base of the wall to permit the river to pass will be sealed before the end of this year. By mid-1959 the stored water will be more than half-way up the 400-foot-high wall, which itself will then be complete—eight months earlier than originally planned.

Peak Effort

The general manager of Impres... Kariba (Pvt.), the main civil engi... eering contractors, told me that the... were now at the peak of their... effort, with 1,000 Europeans and... 5,500 Africans engaged. The num... ber employed would be reduced... steadily from next March. They... had experienced some difficulties... but none of these was insuperable.

The deputy chief executive of... the Federal Power Board estimated... the direct cost of the recent flood... damage at around £500,000. Part... of this, he added, would be recov... erable from insurance. The... indirect costs incurred by accelerat... ing the construction programme... and increasing the number of spill... way gates from four to six would... be somewhat more than £750,000.

On the credit side, the flood had... called attention to the bigger poten... tial of the catchment and this... would result in a small but useful...



The New Power Grid.

...GERMA...
V.T.O. Aircr...
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BY OUR BONN

The German Ministry ... Defence has concluded a licen... agreement with SNECM... Paris, for the development... a coleopter aircraft in Germ... It has given the Baye... Motorenwerke a fully... dised research order, and...

...he borne by the scheme. Amortisation... Stage I are based on amortisation... over 20-30 years—a period unrelated... to the true life of the plant and civil... works. However, the high load factor... to be expected must eventually make... Kariba power one of the world's... cheapest sources of energy.

Meanwhile the new Federal grid... is rapidly taking shape. The trunk...

The first of the six... power turbines, being supplied by... Boving, is now being erected at the... site and the first of the six 100mW... generators to be manufactured by... Metropolitan-Vickers will be shipped... from Britain next February. Two... 200-ton overhead electric travelling... cranes supplied by Babcock and... Wilcox for handling the plant in the...

...to build jet engines ... Défence Ministry are ... Benz, M.A.N. and B.... two years these compan... discussed with the Min... Defence who is to pay ... development costs and fac... such as testing machi...

...PLAN
...RANCE
...-YEAR
...GET
...Correspondent
...RIS, Sept. 16.
...e of the French
...n concerns," said
...Press conference
...g. He was intro-
...e Gaulle's Minis-
...f. Pierre Sudreau,
..."revolutionary
...which aims at
...g units at reason-
...gradually clearing
...ris and the larger

...ent hopes to put
...a year on to the
...from £15 to £25
...year only 70,000
...were built in the
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...uildings will be
...of controls for 25
...d companies (these
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...hich will be con-
...State, though not
...d, to finance, build
...partment blocks and
...s.
...ject announced to-day
...building their own
...row from the Credit
...ed rates of interest—
...or inexpensive working-
...ses, and 3.75 per cent.
...s dwellings.

...drive

...Japan produces both
...d reflex cameras, the
...f the industry is the
...nature camera. In 1957,
...m: cameras were pro-
...a all other types put

...the more ...
...hop...

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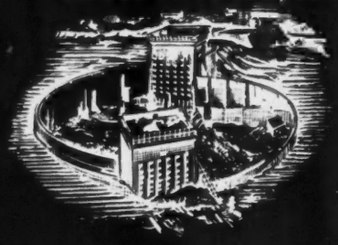
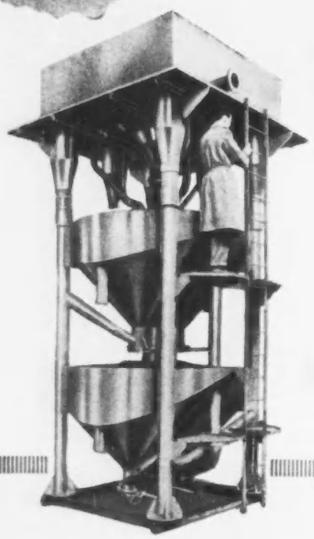
are in use at KARIBA GORGE on the Zambesi River, boundary between Southern and Northern Rhodesia, where Africa's largest Hydro-Electric Power Station is being built. RHEAX past and present installations also include Ybbs-Persenbeug Austria, Zervreila Switzerland, Serre Poncon France, Luenersee Austria, Campo Moro Italy, Gioveretto Italy, Gougra Switzerland, Roselend France, Malvaglia Italy, Jochenstein Austria, Grandval France, Kaprun Austria, Vaiont Italy, Mae Italy, Frera Italy



Classified Sands mean better concrete



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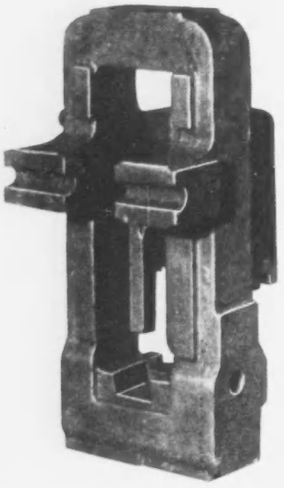
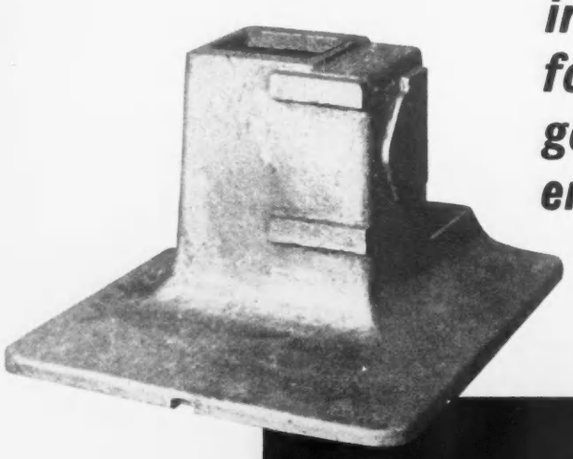
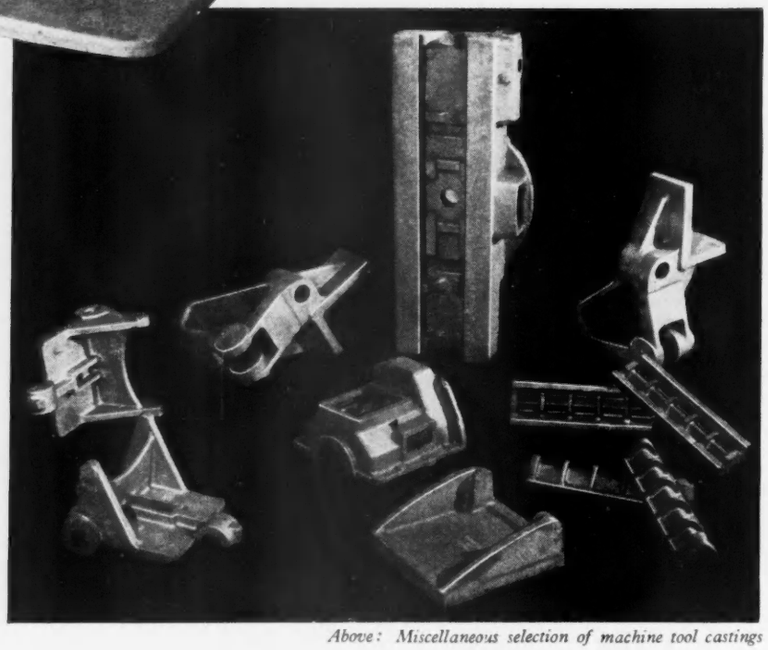
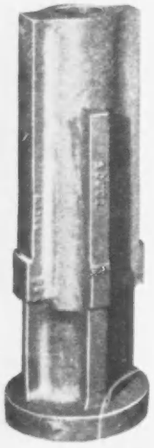


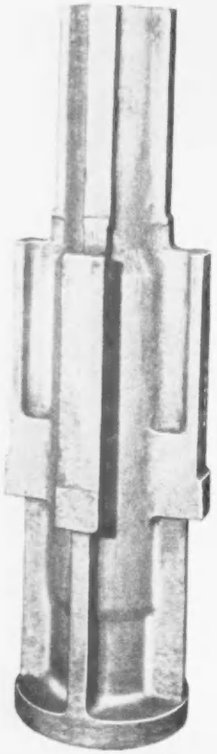


Extreme left : Small machine frame, weight 770 lb.
Left : Machine base, weight 910 lb.



Above : Miscellaneous selection of machine tool castings weighing from 20 to 360 lb.





Left : Armature hubs, weighing from 330 to 920 lb.

We are makers of all types of castings for general engineering and the machine tool trade.

The castings shown in these illustrations are made in varying grades of "Meehanite" to meet customers' requirements, and show consistently good machining qualities.

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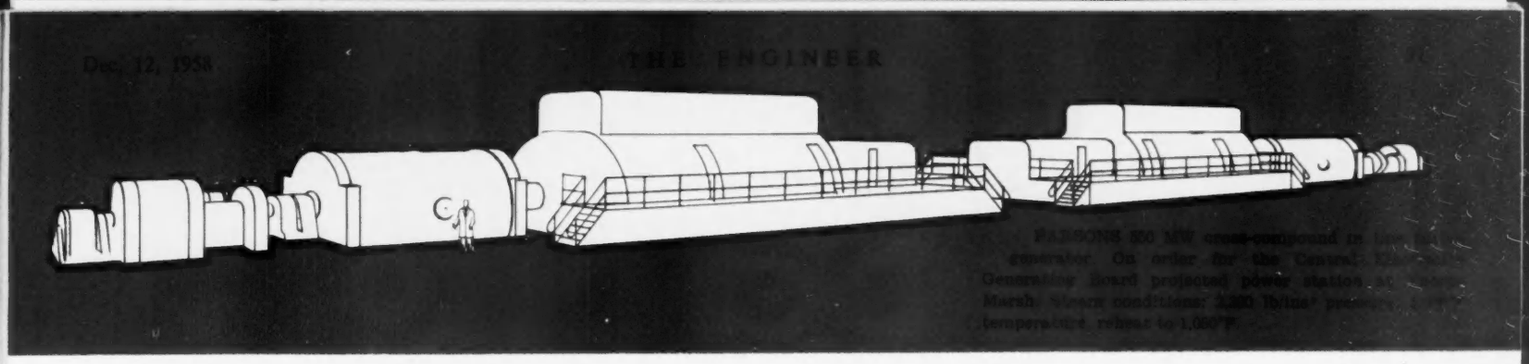
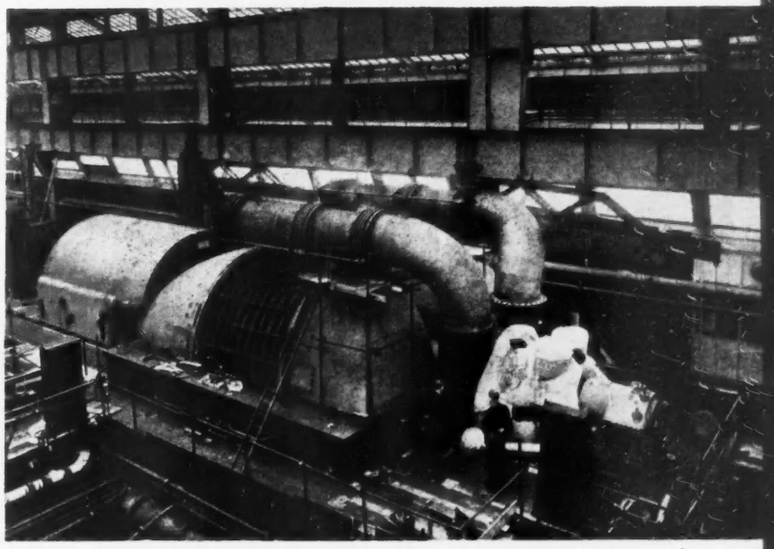
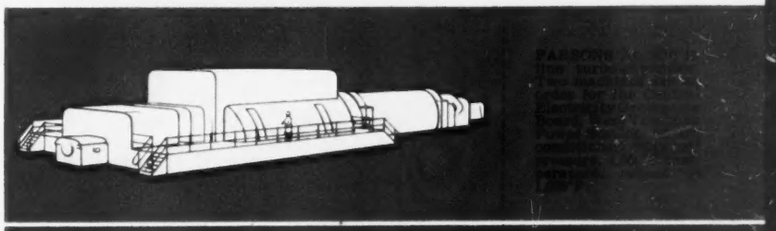


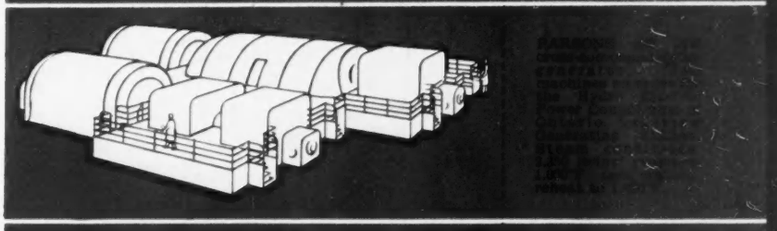
Increasing power output

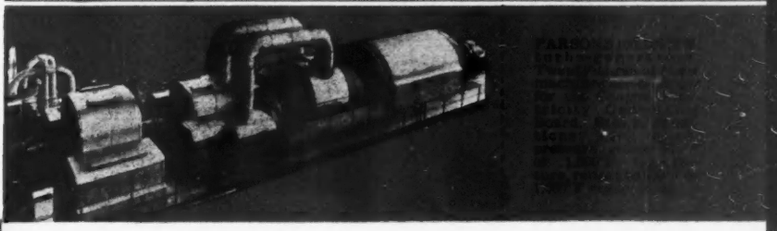
A significant development in the design of steam turbo-generators for power stations is the increase in the power output of individual machines. This is evident in the range of large turbo-generators now under construction at Heaton Works.



PARSONS 200 MW cross-compound turbo-generator (View of low pressure line only). Four of these machines are under construction for the Hydro Electric Power Commission of Ontario, Richard L. Hearn Generating Station. Steam conditions: 1,800 lb/ins² pressure, 1,000°F temperature, reheat to 1,000°F.







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TURBO-GENERATORS

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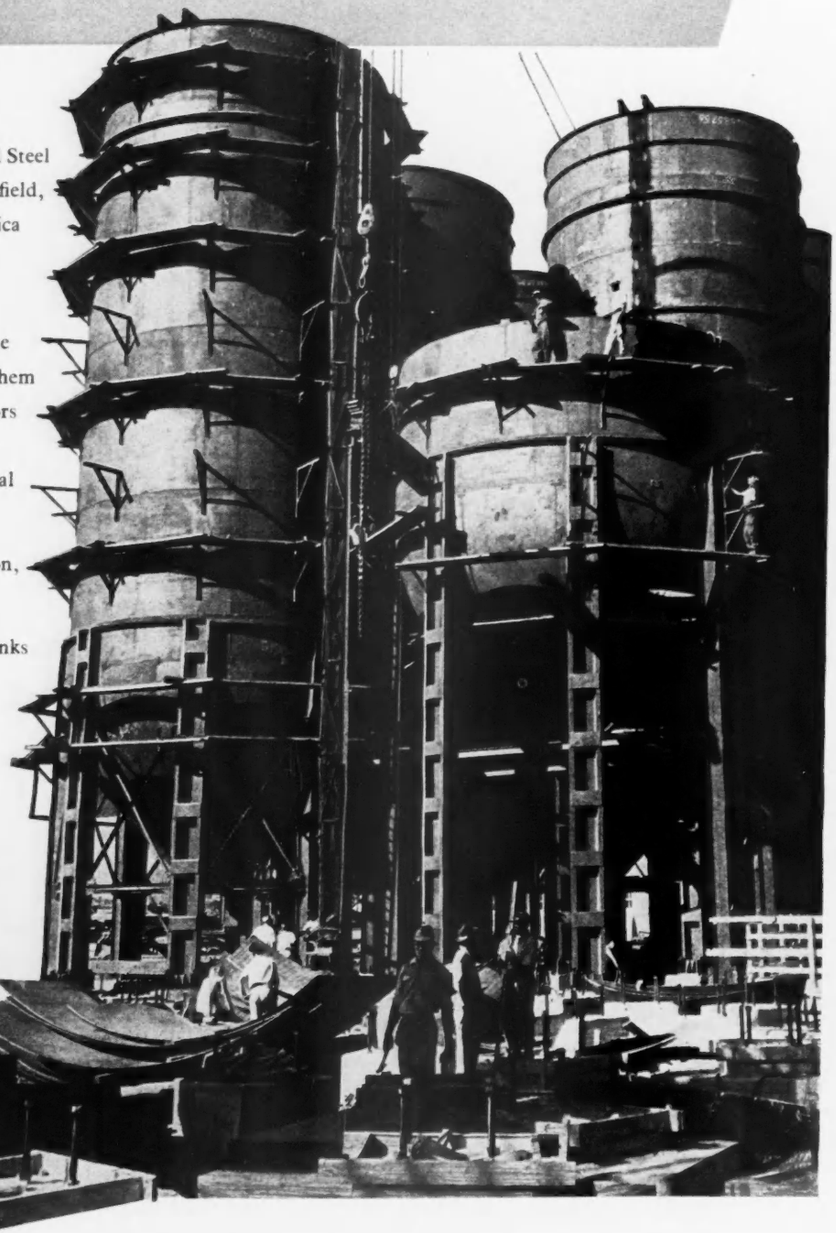
STEEL PRODUCTS OF INTERNATIONAL REPUTE

South Durham in JAMAICA



Here is one small part of an installation of Welded Steel Precipitator Tanks in course of erection at Williamsfield, Jamaica, at the Kirkvine Works of Alumina Jamaica Ltd. The tanks were manufactured at the South Durham Malleable Works, Stockton-on-Tees.

After fabrication and test assembly at Stockton, the component parts were shipped to Jamaica. With them went a full crew of South Durham's trained erectors and welders whose tour of duty overseas has since covered the installation of one of the largest mineral processing plants in the western hemisphere.

Work on a similar Alumina Jamaica plant at Ewarton, is now nearing completion.

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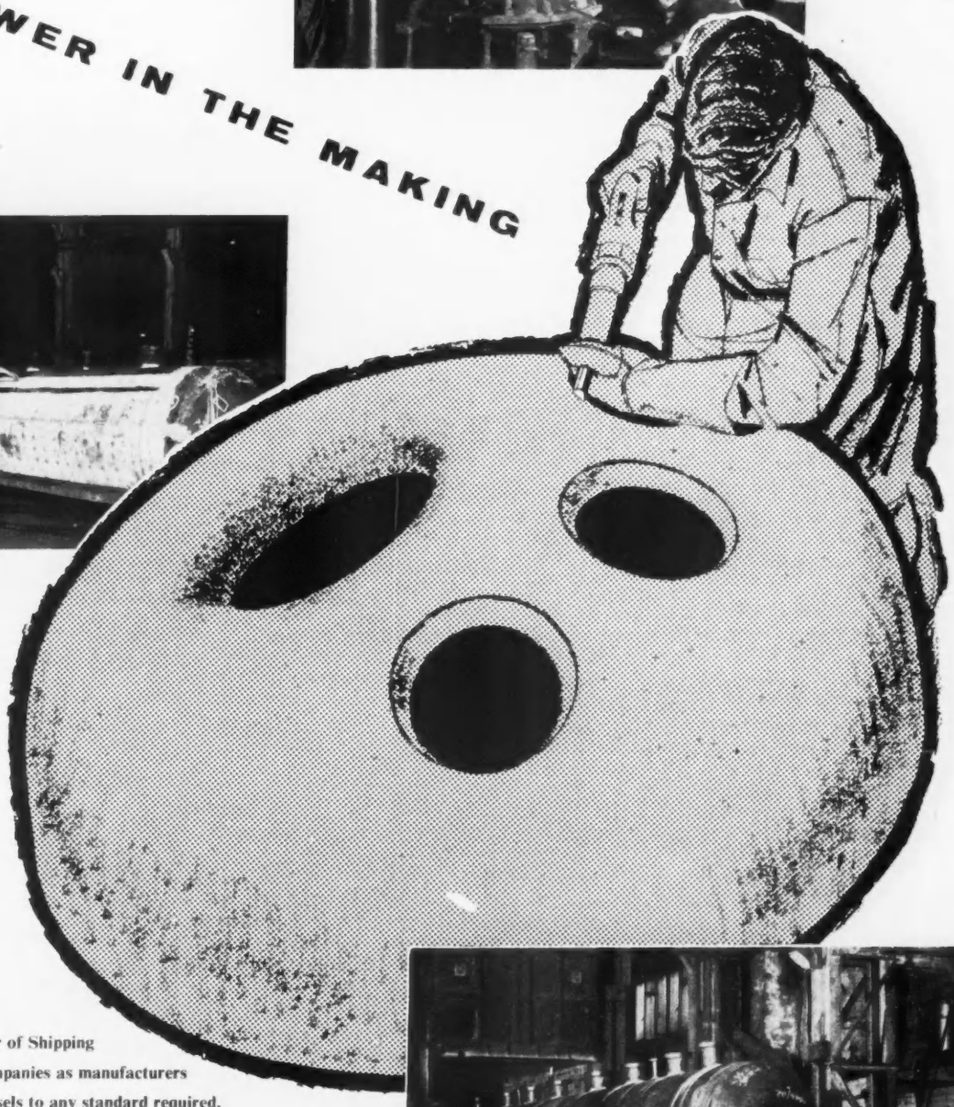

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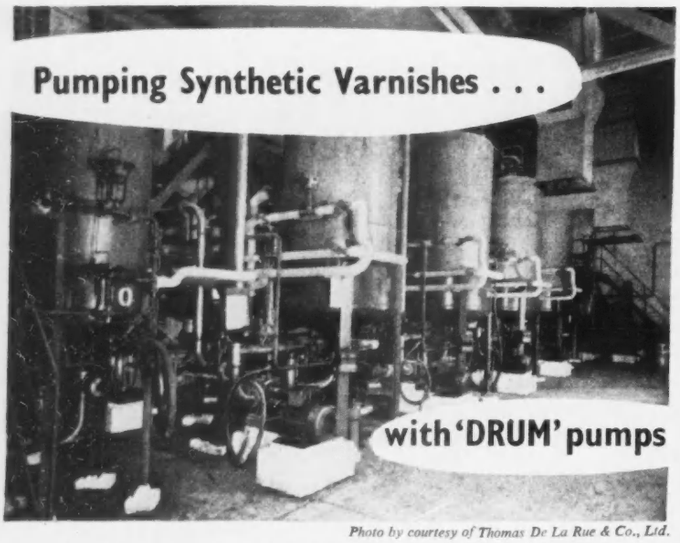

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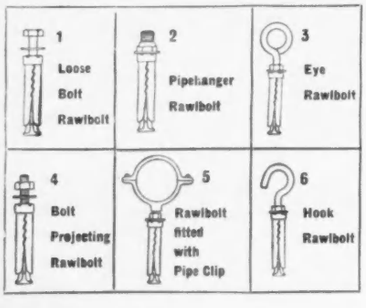

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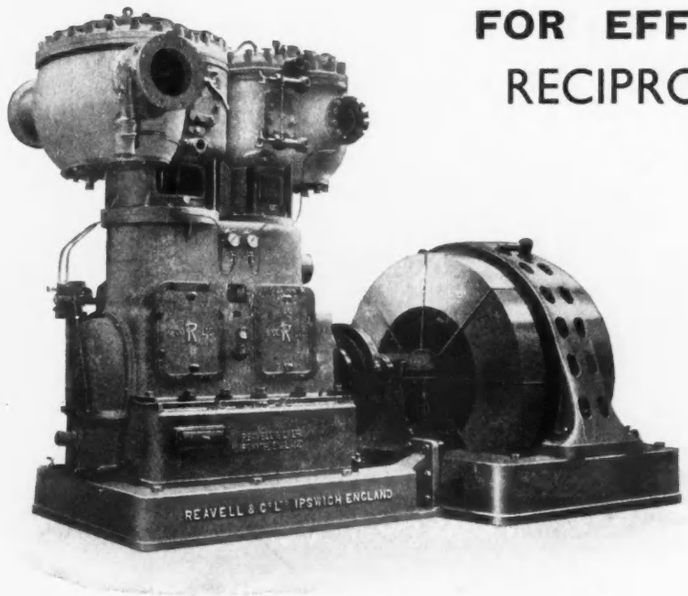

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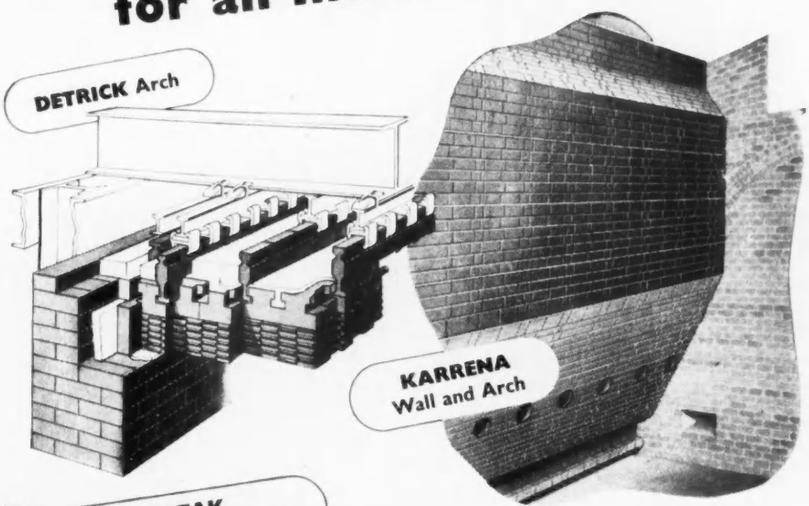

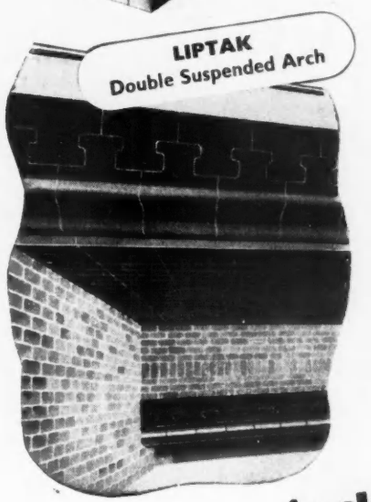

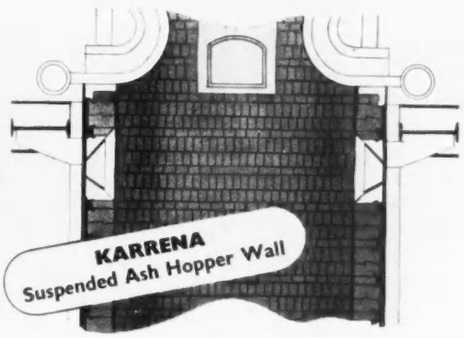

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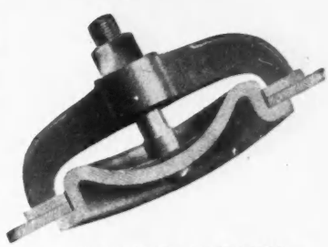

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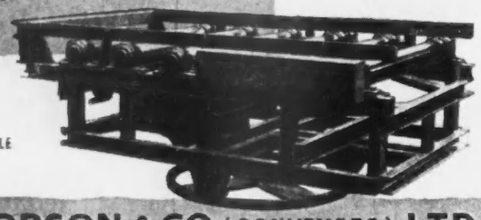

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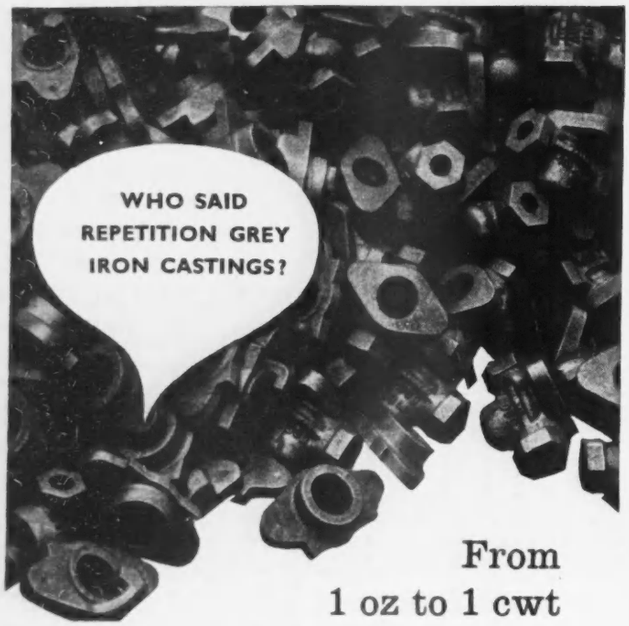

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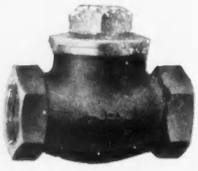

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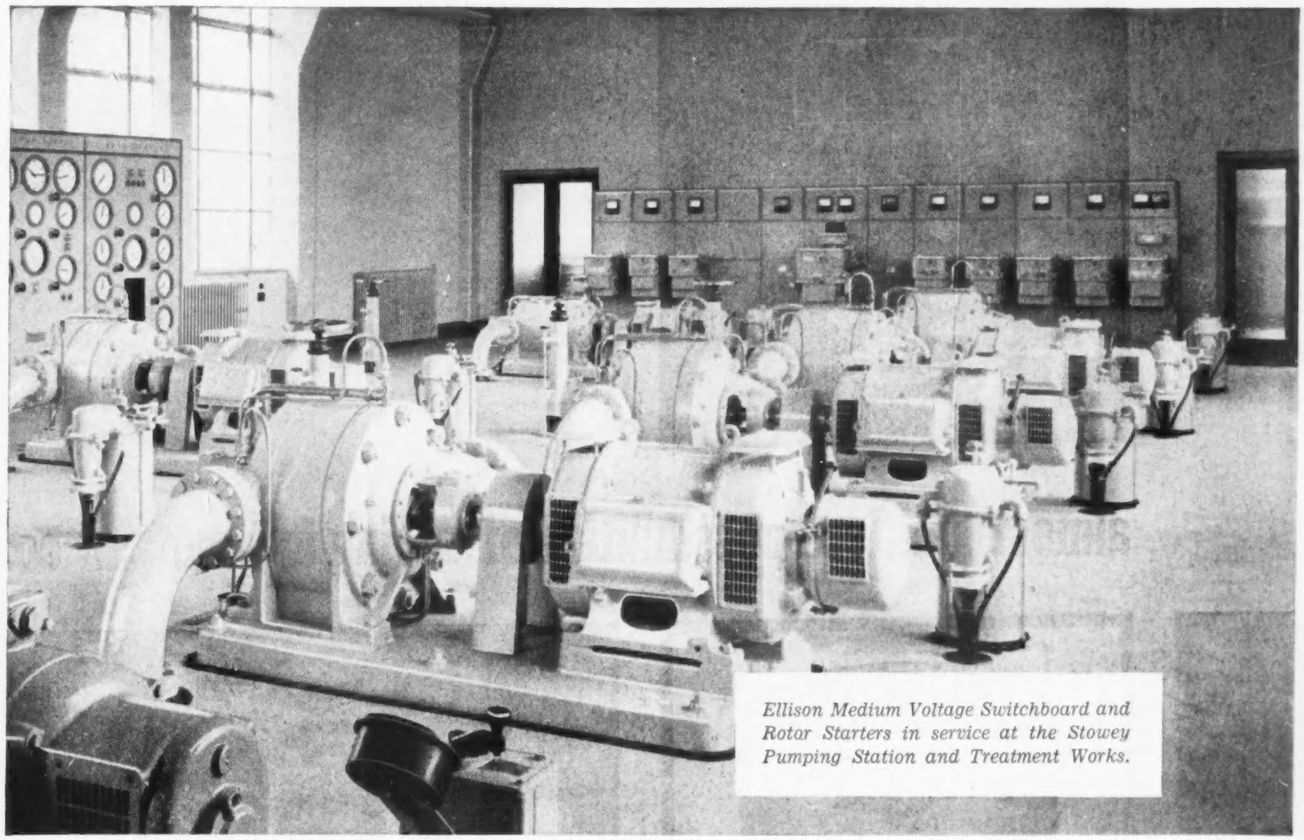

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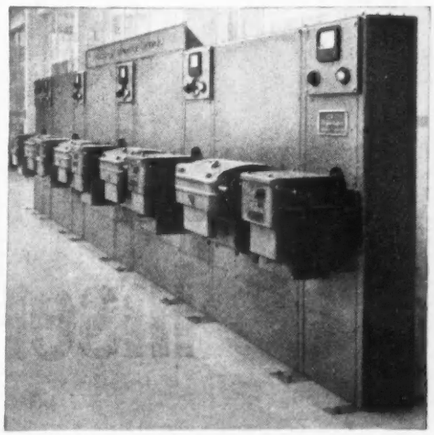

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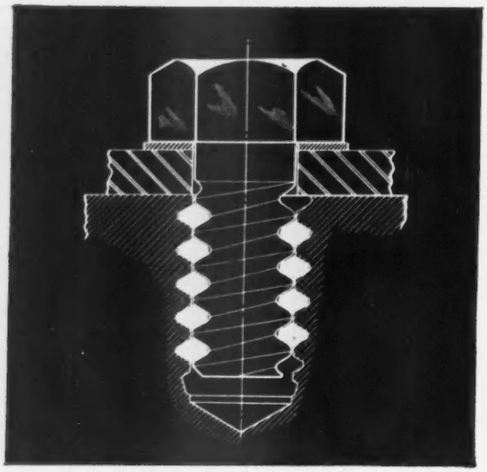

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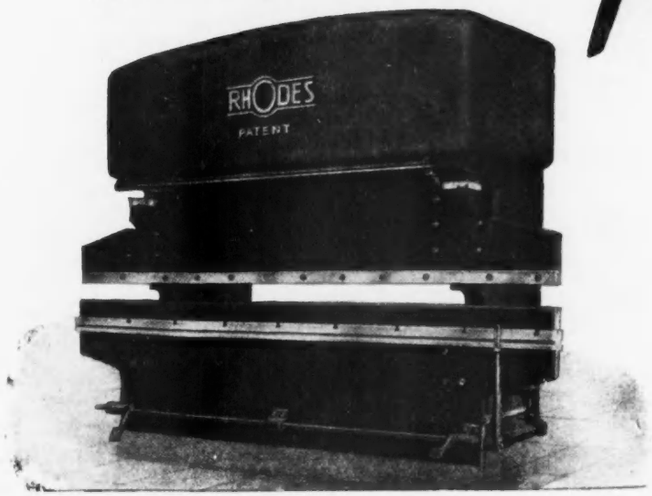

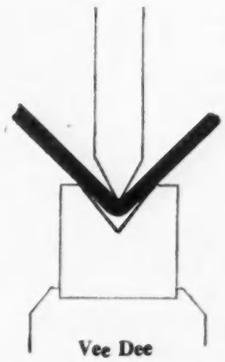

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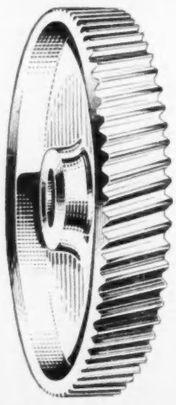

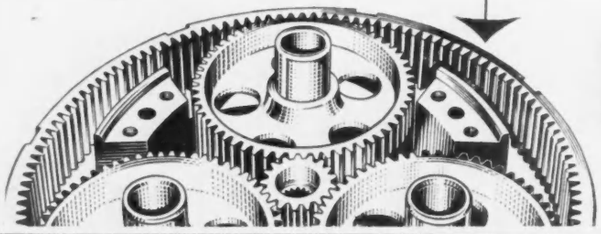

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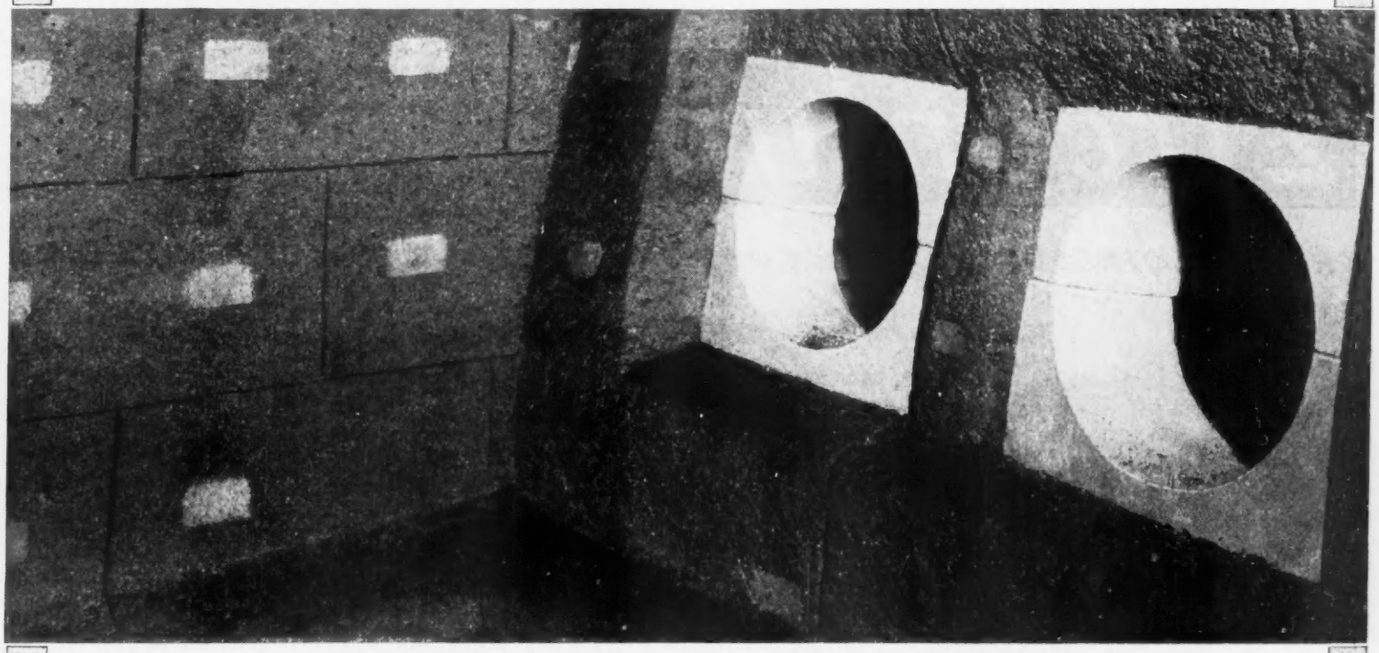

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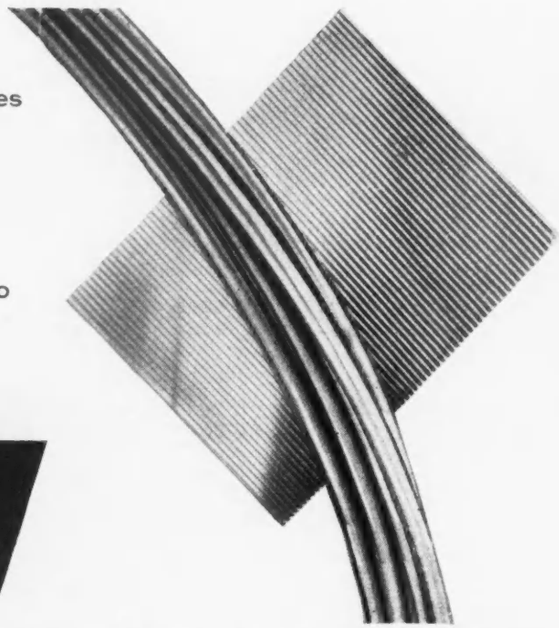

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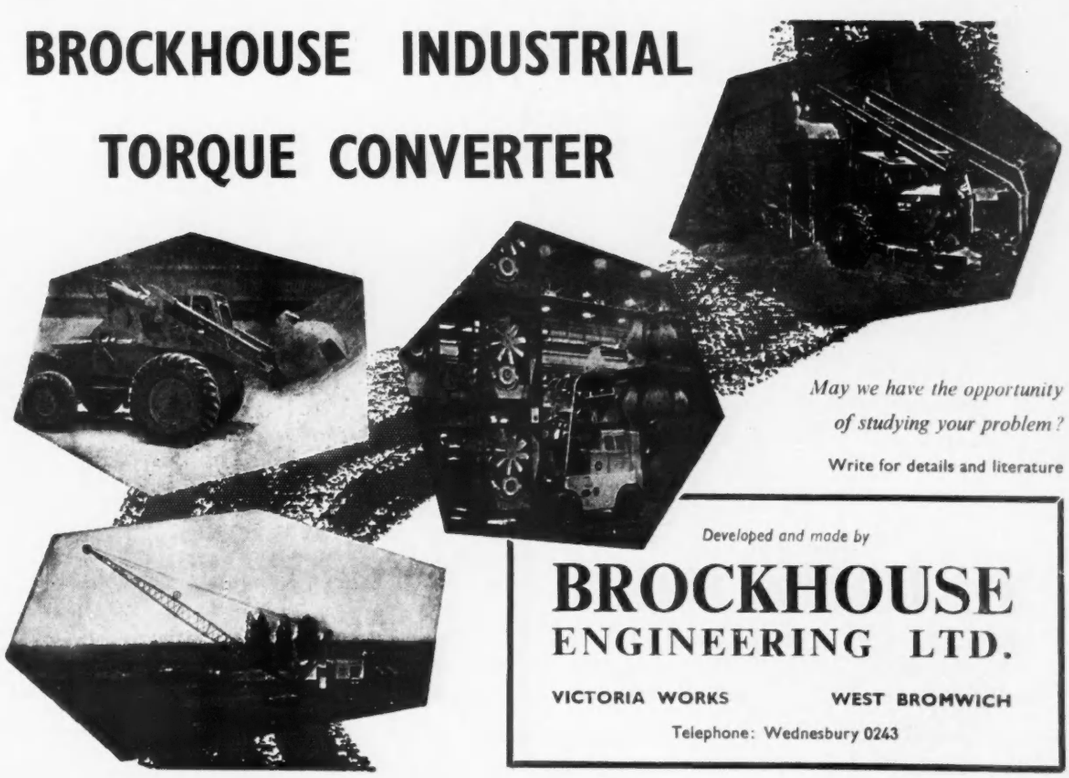

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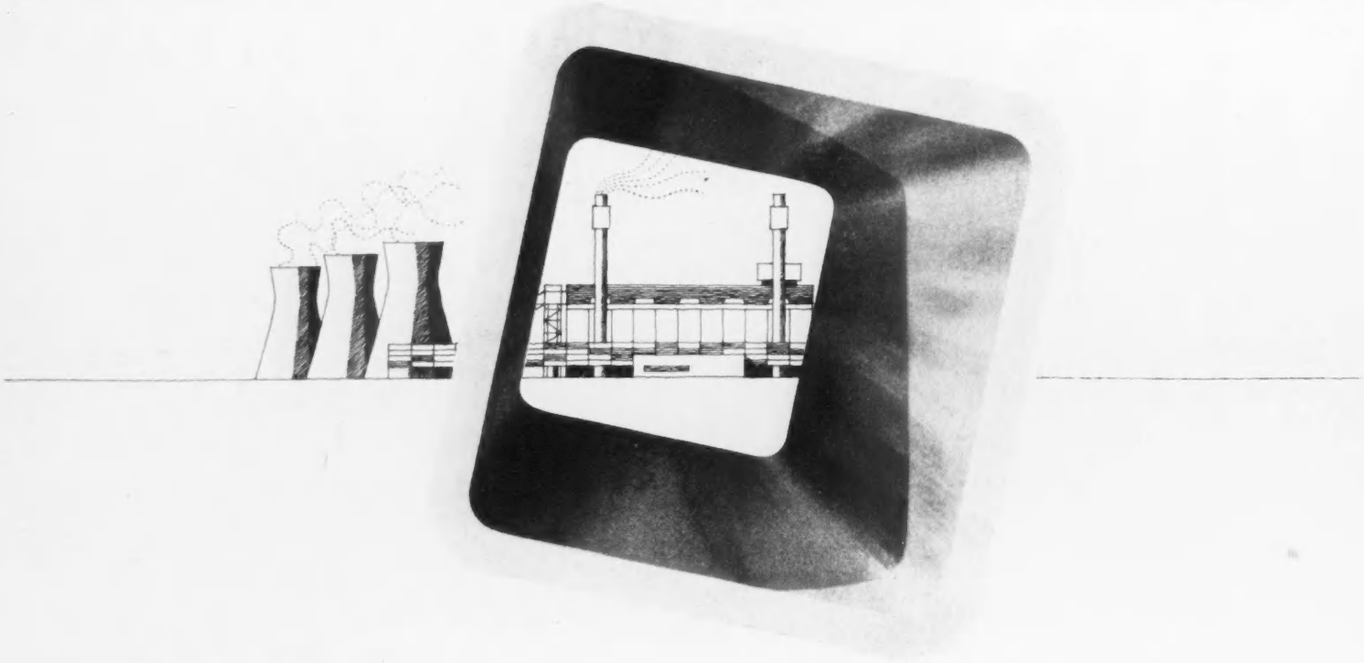

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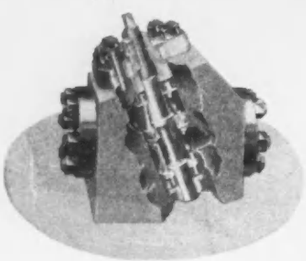
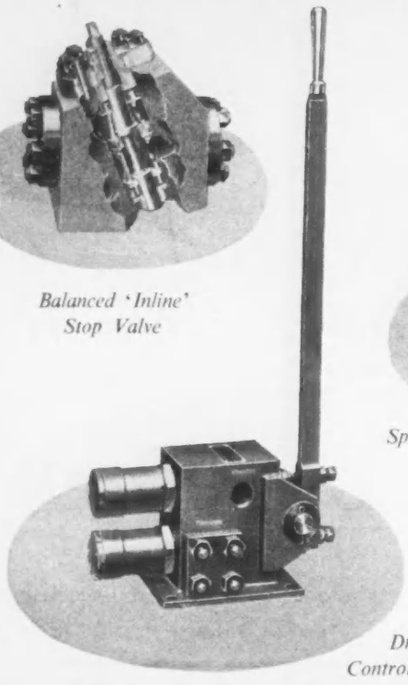
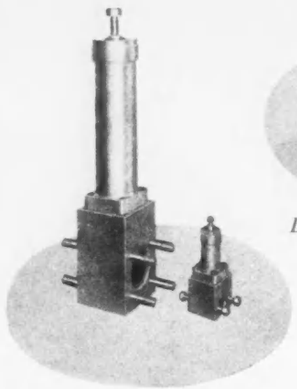


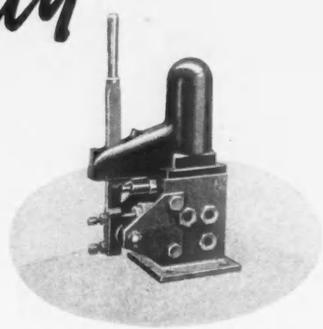
Balanced 'Inline' Stop Valve



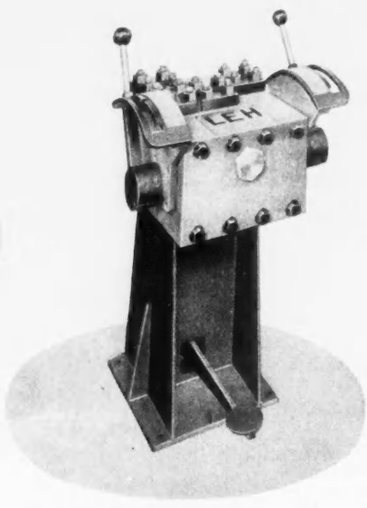
Drop Mitre Control Valve



Spring Loaded Relief Valves



Drop Mitre Control Valve With Trip Gear



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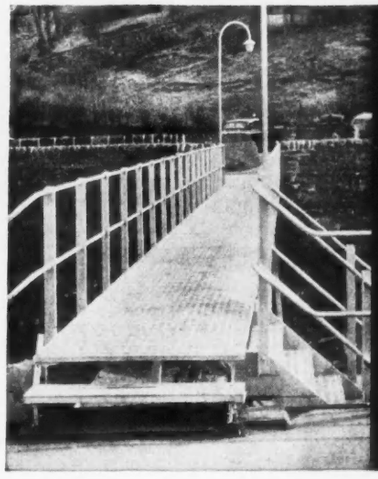

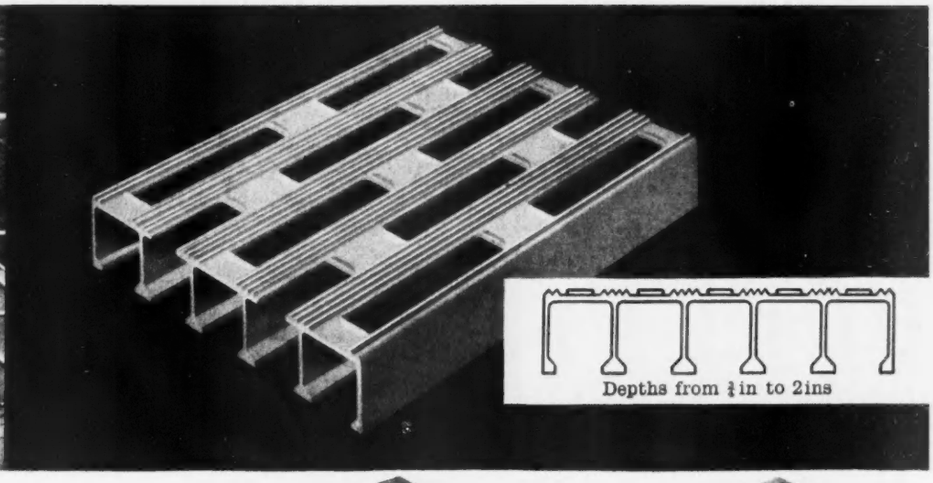

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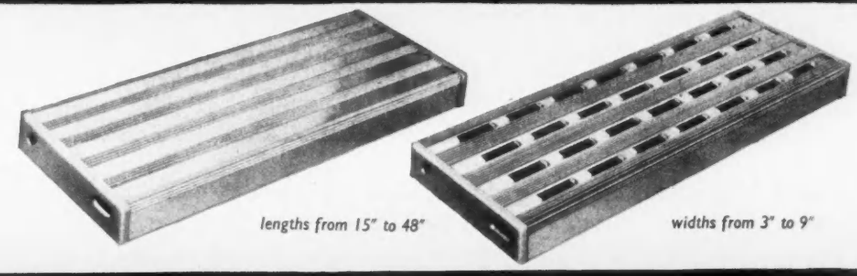

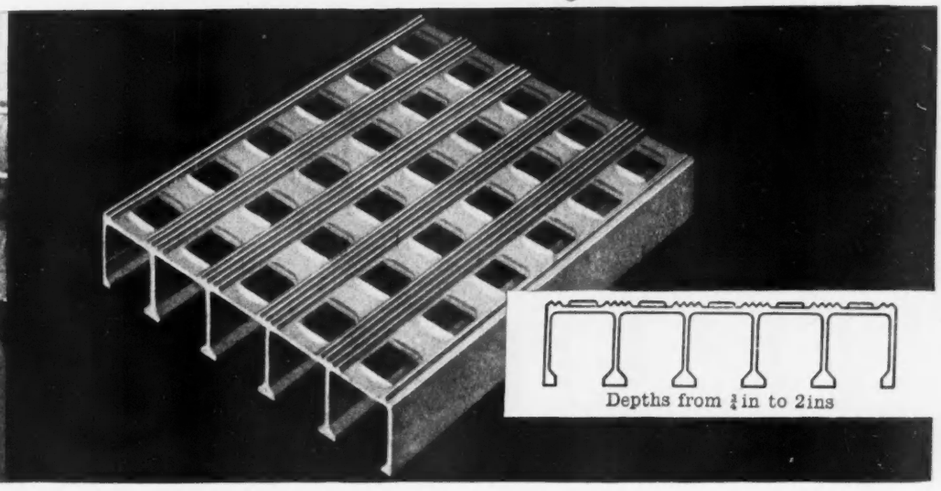

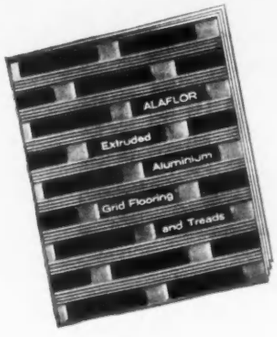

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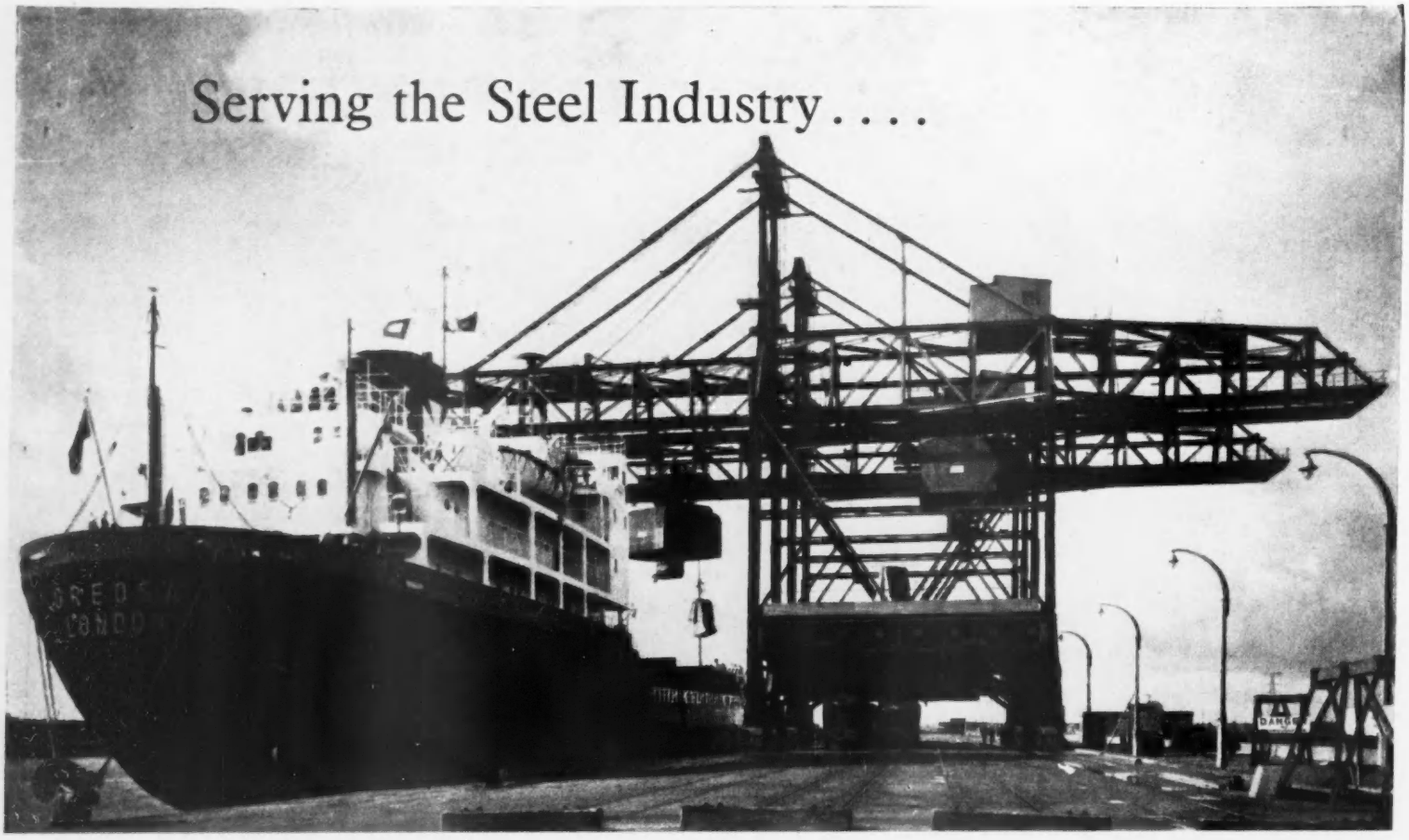

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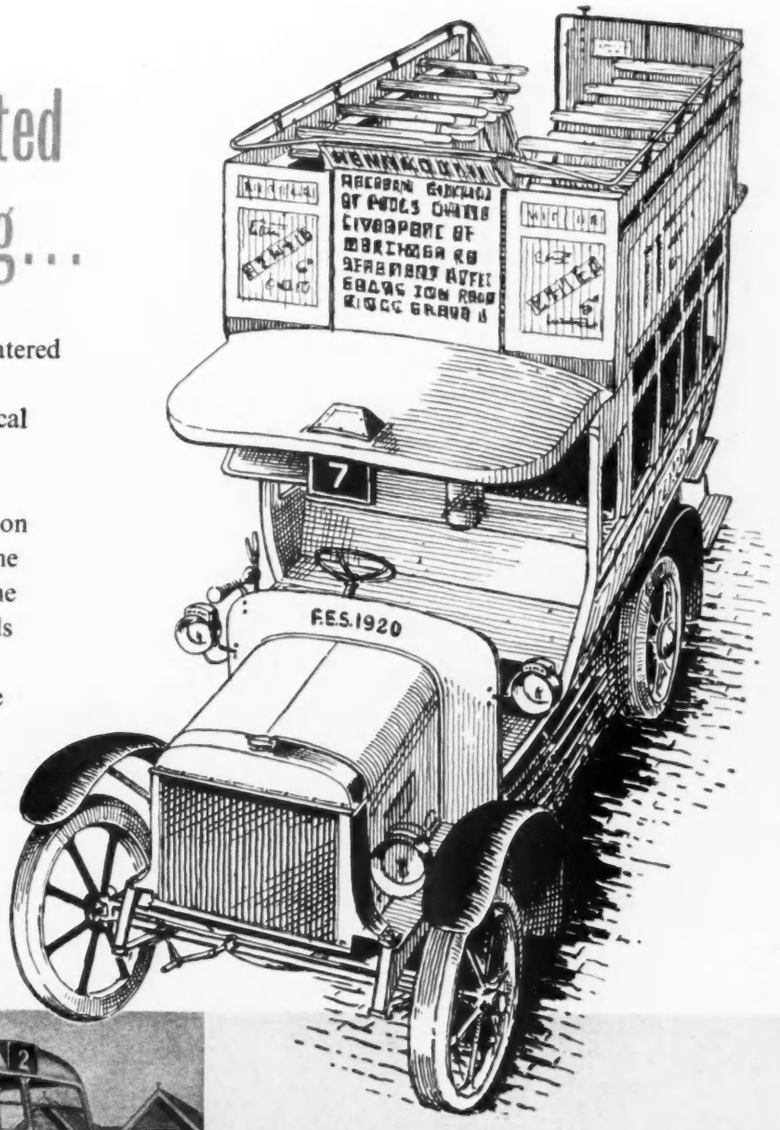

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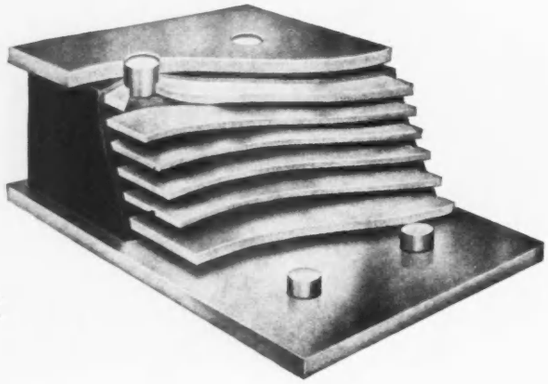

One of the mountings cut away to show the rubber-metal construction.

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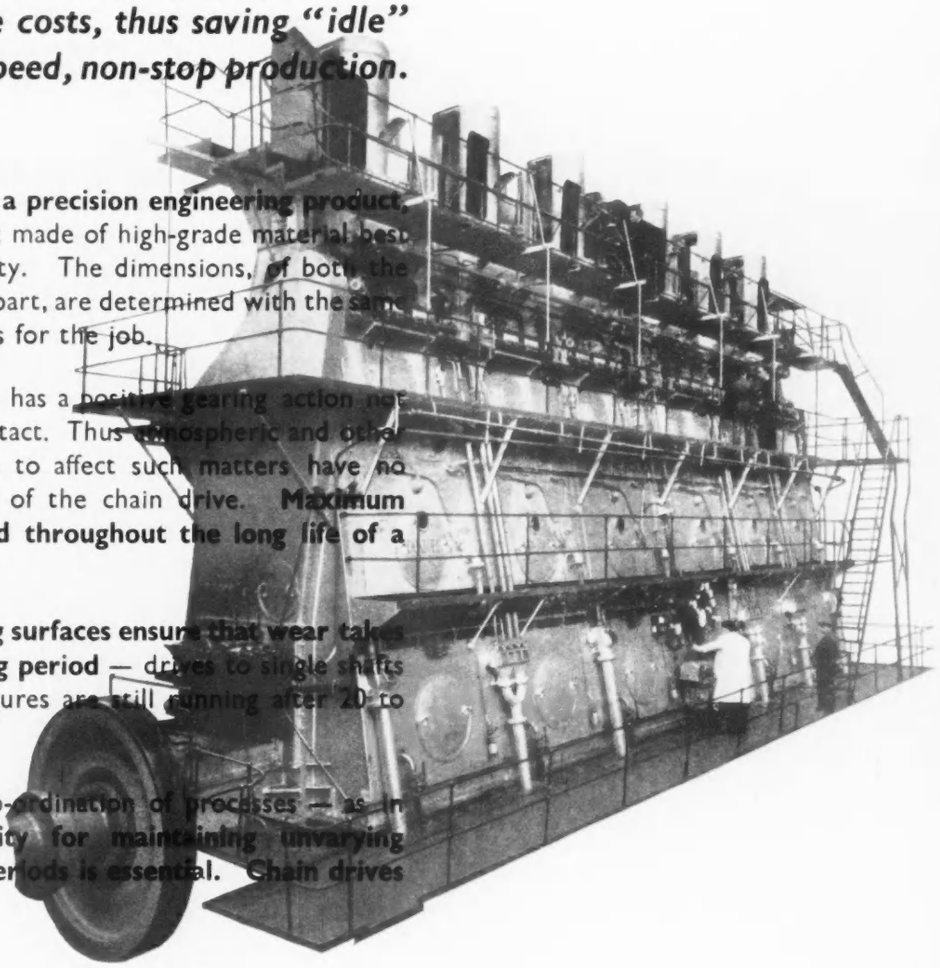

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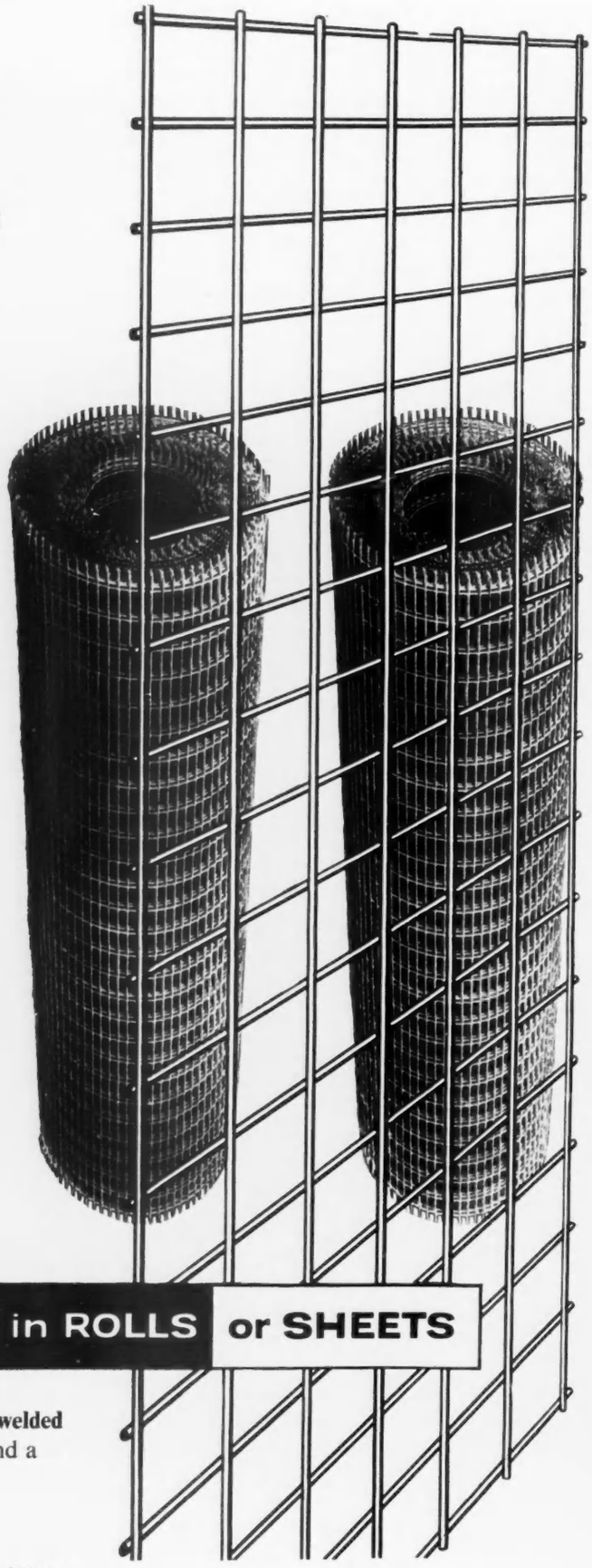

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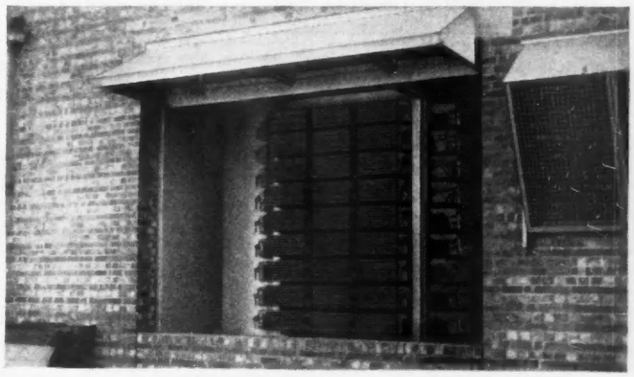
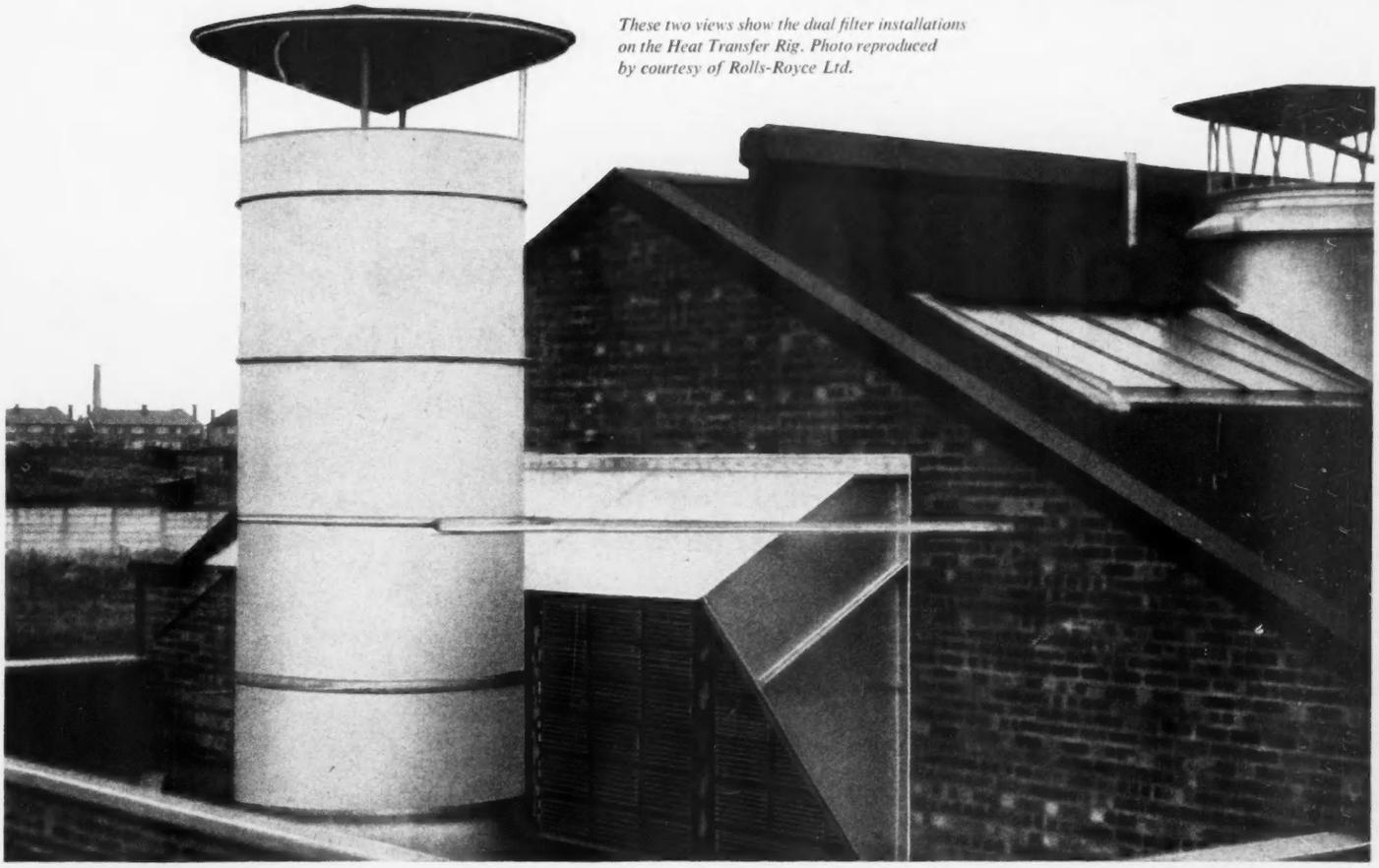


*** When specifying your filtration requirements, we strongly recommend that you request test information against B.S.S. 2831.**

These two views show the dual filter installations on the Heat Transfer Rig. Photo reproduced by courtesy of Rolls-Royce Ltd.



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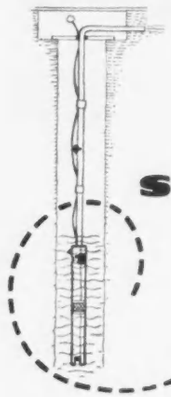

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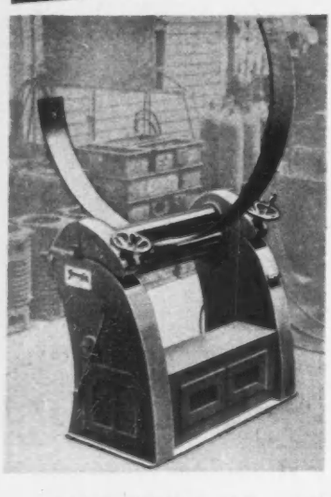

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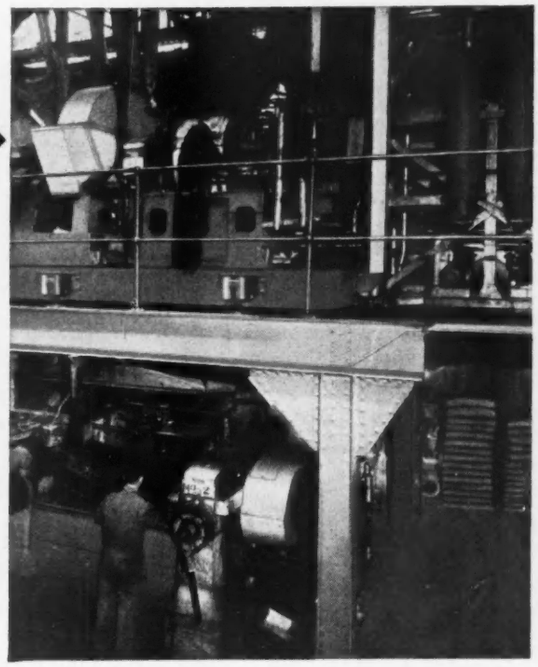

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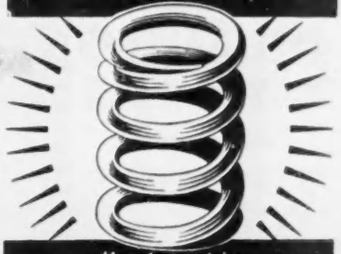

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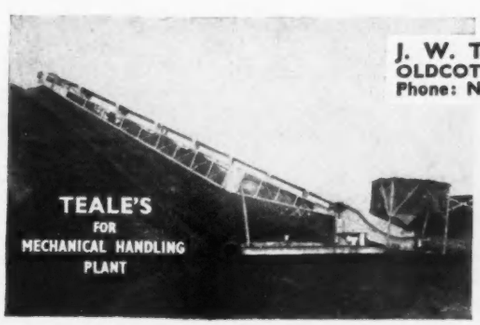

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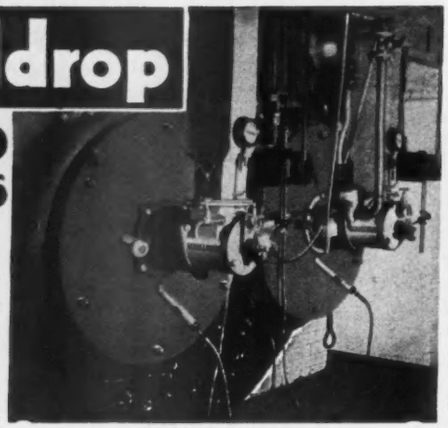

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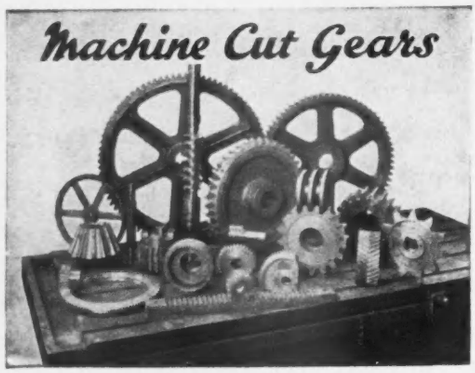

WORMS
RACKS
SCREWS
SILENT GEARS
CHANGE GEARS

All materials standard pitches to 7ft diameter

General machine castings made to customers' patterns. Low prices for planing, boring, turning, screwcutting

Send your enquiries to

GREENWOOD'S STANDARD GEAR CUTTING CO. LTD.,

New Bond Street, Halifax. *Telephone : Halifax 5217/8* *Telegrams: "Gears."*

quality malleable castings B·S·S309

EASILY MACHINEABLE

also

SOFT GREY IRON CASTINGS for all trades

REGD. TRADE MARK

alfred·h MOULD & SONS LIMITED

Our metal is melted under strict metallurgical control in modern Rotary Furnaces and is annealed in up-to-date pulverised coal furnaces ensuring perfect dependability.

STAFFORD STREET · WALSALL · TEL: 3509

SOUTHERN REPRESENTATIVE:
G. P. SANDERSON, LTD.
SANDERSON HOUSE, NORFOLK SQ.
BRIGHTON 1.
PHONE: HOVE 71329.

LANCS, YORKS, CHESHIRE, SHROPSHIRE REPRESENTATIVE:
MALCOLM P. ROWE,
PRUDENTIAL BUILDINGS, ST. PETERSGATE, STOCKPORT, CHESHIRE.
PHONE: STOCKPORT 5512.

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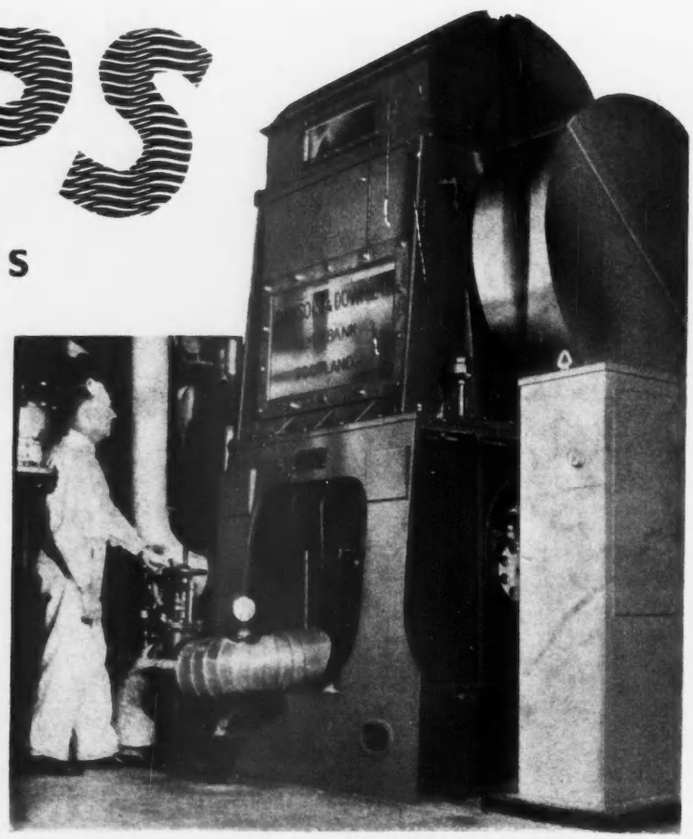
PUMPS

FOR ALL PURPOSES

The vertical high pressure Three Throw Ram Pump illustrated was supplied to Thomas Hedley & Co. Ltd. for use in the manufacture of Tide, Daz and other synthetic detergents.



BOILER FEED PUMPS
VACUUM PUMPS
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ELGIN WORKS
CLYDEBANK

Telephone: 2271-2-3 Clydebank
Telegrams: "PUMPS" CLYDEBANK

WHERE **QUALITY** IS IMPORTANT...

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Corrosion Resistant

NICKEL ALLOYS

are unsurpassed

Please ask for full details of the Langley range of Nickel Alloys for duties where reliability in service is essential

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TELEPHONE: LANgley 432 (7 lines)

LANGLEY *Special* ALLOYS

Rubber Extrusions

IF YOU HAVE A RUBBER PROBLEM—
—WE HAVE AN ANSWER.

CLYDE RUBBER WORKS LTD.

SPECIALISTS IN RAILWAY ROLLING STOCK EQUIPMENT
P.O. BOX 7, RENFREW. *Telephone: Renfrew 2384. Telegrams: Rubber Renfrew Telex 70.*

5852

Increased capacity and

GREATER ROLLING ACCURACY

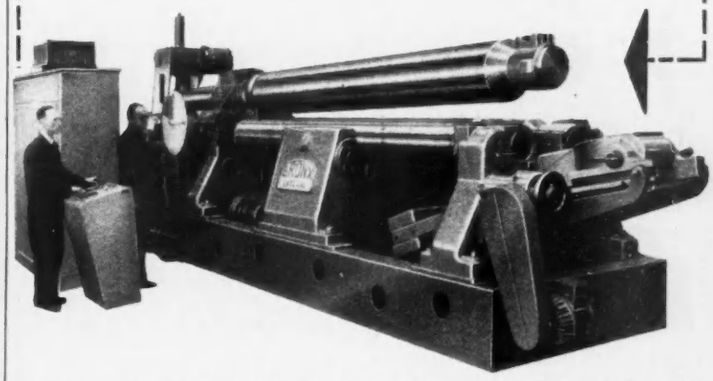

Illustration shows series PBE 810 with swing-down bearing bracket in down position. Photo by courtesy of Consett Iron & Steel Co. Ltd. Durham

● Illustrated is a heavy-duty Bronx three-roll Pyramid Type Plate Bending Roll—complete with a desk type control panel and all the necessary electrical equipment. It is arranged for motor drive and includes an additional top roll which increases the capacity. Vertical rolls are fitted for use in conical rolling. When the machine is fitted with a 16" diameter top roll it is capable of bending mild steel plate 10' wide by 1" thick. With an 18" diameter top roll it can deal with plate 10' wide by 1¼" thick.

There are also Bronx Press Brakes, Guillotines, Plate Levelling Rolls, etc. Write for illustrated catalogues.

BRONX

PLATE BENDING ROLLS

BRITISH THROUGHOUT

BRONX ENGINEERING CO. LTD., LYE, WORCESTERSHIRE

Telephone: LYE 2307 and 2308

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch.
There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

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Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-on and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

WITWATERSRAND TECHNICAL COLLEGE

JOHANNESBURG

Director: Dr. A. W. ROWE, M.Sc., M.I.Mech.E., M.I.E.E.

LECTURER IN APPLIED THERMODYNAMICS

Applications are invited for the post of LECTURER IN APPLIED THERMODYNAMICS.

Applicants must possess a degree in Mechanical Engineering or equivalent qualification and should have had some years experience with steam plant and internal combustion engines.

The post is a responsible one and entails lecturing and laboratory work for technicians and other advanced technical students.

Salary Scale: £700 by £50 to £900 by £60 to £1440, plus 5 per cent. annual vacation savings bonus. Commencing salary will depend on qualifications and experience.

Duties to commence 1st February, 1959.

College will pay half salary from date of sailing to date of assuming duty, plus reasonable travelling expenses for successful applicant.

Forms of application, which may be obtained from Messrs. Frank Ross and Co. (London), Ltd., Marlow House, Lloyd's Avenue, London, E.C.3, should be completed and submitted to The Director, Witwatersrand Technical College, P.O. Box 3293, Johannesburg, South Africa, as soon as possible. E9297

READING TECHNICAL COLLEGE

DEPARTMENT OF ENGINEERING

LECTURER

Applications are invited for the post of LECTURER in the Department of Engineering to teach subjects in the O.N.C. Mechanical Engineering Course and one or more of the following at A.I level: Theory of Machines, Theory of Structures, Mechanics of Fluids, Strength of Materials. Applicants must have a Degree or equivalent and must have had full or part-time teaching experience, preferably in a Technical College. Scale £1200 by £30 to £1350.

Further particulars and application forms, returnable by 31st December, 1958, obtainable from the Principal, Reading Technical College, King's Road, Reading. E9395

UNIVERSITY OF LIVERPOOL

LECTURER

Applications are invited for the post of LECTURER in the Department of Building Science at an initial salary within the range £900–£1350 per annum, according to qualifications and experience. Applicants should have an Honours Degree in Civil Engineering and have had experience with a firm of contractors.

Applications, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than 29th January, 1959, by the Registrar, from whom further particulars of the conditions of appointment may be obtained. E9359

SURREY EDUCATION COMMITTEE

RICHMOND INSTITUTE OF FURTHER EDUCATION, KEW ROAD, RICHMOND

APPOINTMENTS

Applications are invited from suitably qualified men to teach Workshop Technology, Workshop Practice and allied subjects leading to C. and G. Machine Shop Engineering Intermediate standard, to part-time day release students. Burnham Scale for Grade "A" Assistants, plus London allowance and allowance for industrial experience.

Application form from Principal, to be returned as soon as possible. E9401

PUBLIC APPOINTMENTS

SURREY EDUCATION COMMITTEE

WIMBLEDON TECHNICAL COLLEGE, GLADSTONE ROAD, S.W.19

LECTURER

LECTURER required in January, 1959, to teach Mechanical Engineering subjects to Higher National Certificate level. Applicants should be Graduates with suitable teaching and industrial experience. Salary, Burnham Scale, £1200 by £30 to £1350, plus London allowance.

Application form and further particulars obtainable from the Principal, to whom completed applications should be sent within two weeks of the appearance of this advertisement. E9400

UNIVERSITY OF SHEFFIELD

SENIOR LECTURER IN MECHANICAL ENGINEERING

Applications are invited for a post of SENIOR LECTURER IN MECHANICAL ENGINEERING, to begin duties on 1st April, 1959, or as soon as possible thereafter. Initial salary on the scale £1650 by £75 to £2025, according to qualifications and experience, with F.S.S.U. provision and family allowance.

Further particulars should be obtained from the Registrar to whom applications (two copies, one only from overseas candidates) should be sent by 31st January, 1959. E9239

SHIPSTON-ON-STOUR RURAL DISTRICT COUNCIL

ILMINGTON SEWERAGE SCHEME PART II

APPOINTMENT OF
RESIDENT ENGINEER

Applications are invited for the appointment of RESIDENT ENGINEER in connection with the laying of 6in. diameter salt glazed ware sewers, construction of manholes and sewage disposal works, at Ilmington, near Shipston-on-Stour.

The works are being executed by Contract under the direction of the Council's Surveyor. The salary will be between £850 and £1000 per annum, according to qualifications and experience. The appointment, subject to satisfactory service, is expected to last 12 months and will be terminable by one month's notice, in writing, on either side. A mileage allowance will be paid on the essential user scale for a car not exceeding 10 h.p. or 1199 c.c.

Applicants, who should have had experience of similar work, should apply in writing to the undersigned not later than 27th December, 1958, giving full particulars of age, qualifications and experience, date when available and copies of not less than two recent testimonials.

W. BOOTH,
Clerk of the Council.

Council Offices,
Shipston-on-Stour,
Warwickshire.
8th December, 1958. E9405

CITY OF LIVERPOOL

MARKETS DEPARTMENT

ASSISTANT GENERAL ENGINEER

Applications are invited for the appointment of ASSISTANT GENERAL ENGINEER at the Stanley Abattoir.

Salary within the scale £575–£845 (A.P.T. I/II), according to qualifications and experience.

Applicants should possess one or more of the following qualifications: Institution of Mechanical Engineers—Intermediate; Board of Trade Certificate, 2nd Class; Ordinary National Certificate.

Application forms (returnable by 20th December, 1958), and further particulars obtainable from the General Manager, City Markets Department, Stanley Abattoir, Liverpool, 13.

The appointment is superannuable and subject to the Standing Orders of the City Council. Canvassing disqualifies.

THOMAS ALKER,
Town Clerk.

(J.5422) E9382

PUBLIC APPOINTMENTS

FARNHAM GROUP HOSPITAL MANAGEMENT COMMITTEE

APPOINTMENT OF
SUPERINTENDENT ENGINEER

Applications invited for this post vacant on 1st April, 1959. New entrants to the service must have a thorough practical mechanical engineering training, knowledge of the operation of steam boiler plants, and supervisory experience of mechanical and electrical engineering services, should have passed an examination in engineering technology and hold one of the following qualifications or approved equivalent, viz.: M.T.C.A. First Class Certificate of Competency in Marine Engineering; M.T.C.A. Certificate of Service as First Class Engineer; City and Guilds full Technological Certificate in Plant Engineering (First Class).

The post includes responsibility for the supervision of building maintenance work in the Group. Salary scale £855/£1005, with National Health Service conditions of service. Full details of age, experience and qualifications, with names of three referees, to Group Secretary, Farnham Hospital, Farnham, Surrey, not later than 31st December, 1958. E9362

CIVIL SERVICE COMMISSION

PATENT OFFICE

EXAMINERS

Patent Office: EXAMINERS (men and women) for scientific, technical and legal work on Patent applications. Age between 21 and 35; extension for regular Forces service and Overseas Civil Service. Qualifications: normally first or second class honours degree in physics, chemistry, engineering, metallurgy or mathematics, or equivalent attainment or professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. London salary (men) £635–£1410; provision for starting pay above minimum. Good promotion prospects.—Apply Civil Service Commission, 30, Old Burlington Street, London, W.1, for application form, quoting S128/58 and stating date of birth. E9374

ATOMIC ENERGY RESEARCH ESTABLISHMENT

HARWELL

GRADUATE MATHEMATICIANS

GRADUATE MATHEMATICIANS are required for work on the numerical analysis and programming of a wide range of problems in mathematical physics. Computing machines available include a Ferranti "Mercury," I.B.M.704 and B.T.M.555 electronic calculator. There are vacancies in the Scientific Officer class (a First or good Second Honours Degree required) at salaries up to £1425, and in the Experimental Officer class at salaries between £520 and £1215.

Please send a POST CARD to the Group Recruitment Officer (1261/25), U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Berks, for further details of these opportunities. E9351

WEST KENT MAIN SEWERAGE BOARD

SENIOR ENGINEERING ASSISTANT

SENIOR ENGINEERING ASSISTANT (£780–£1060) (Special Grade with London allowance). Commencing salary according to ability. N.J.C. conditions of service. Local Government superannuation. Qualifications: University Degree in Engineering or Graduate Membership of I.C.E. Work includes design of sewers and reinforced concrete structures. Applications, giving full personal details, particulars of education, training and experience, and the names and addresses of two referees, should reach me within ten days of the publication of this advertisement.

A. J. W. JEFFERY,
Secretary of the Board.

20, Blyth Road,
Bromley, Kent. E9363

PUBLIC APPOINTMENTS

METROPOLITAN BOROUGH OF WANDSWORTH

APPOINTMENTS

Applications invited for established posts within the grades shown:

(a) SENIOR ASSISTANT ENGINEER, A.P.T. V, £1205–£1355.

(b) THREE ASSISTANT ENGINEERS, Special Grade, £780–£1060.

(c) ENGINEER AND SURVEYORS' ASSISTANT, A.P.T. I, £605–£755.

(d) ENGINEERING ASSISTANT, APT. I, £605–£755.

(e) DRAUGHTSMAN, Misc. III/VI, £535–£775.

Applicants for (a) must be either associate members of the I.C.E., or the I.M.E., with considerable experience of municipal engineering works, including sewers. Applicants for (b) must have passed the final examination of one of those professional bodies, or possess a degree in engineering and have at least five years' experience including training. Applicants for (c) must have completed training as envisaged in the scheme for training of municipal engineers, or be required to complete such training and passed the inter examination of one of the above bodies, or be university graduates. Applicants for (d) must be neat draughtsmen with experience in civil engineering works. Experience of estimating, and knowledge of electrical and/or mechanical work an advantage. Applicants for (e) must possess experience in a drawing office on civil engineering works.

Application forms from Borough Engineer to be returned by 5th January.

R. H. JERMAN,
Town Clerk.

Municipal Buildings,
S.W.18. E9377

SARAWAK GOVERNMENT MARINE DEPARTMENT

INSPECTOR OF LIGHTS

INSPECTOR OF LIGHTS required by Sarawak Government Marine Department, either on probation to pensionable establishment or on contract with gratuity of 12½ per cent. of final monthly salary for each completed month of service. Salary scale (including inducement pay) equivalent to £1176 to £1932 a year. Child allowance between £72 and £123 a year. Education allowance up to £280 a year. Outfit allowance £60. Free passages. Liberal leave on full salary. Candidates, preferably under 35 and A.M.I.E.E. or A.M.I.Mech.E., should have a good all-round knowledge of electricity especially in connection with the operation of lighthouse flashers (Chance/Londex), Reed and Klaxon motors, echo-sounding gear, otherwise straightforward small unit diesel-electric generation, current conversion, &c., a knowledge and experience of small diesel engines, working knowledge V.H.F. radio equipment, and have a good head for heights up to 130ft.—Write to the Crown Agents, 4, Millbank, London, S.W.1, State age, name in block letters, full qualifications and experience, and quote M2A/50186/EH. E9369

MINISTRY OF SUPPLY

BOSCOMBE DOWN, WILTSHIRE

TECHNICIAN

Ministry of Supply require TECHNICIAN at Boscombe Down, Wiltshire, to be responsible to engineer-in-charge, for control of inspection in group of workshops supporting Experimental Establishment in manufacture of test equipment, and servicing, modification and repair of wide range of equipment used in support of aircraft engaged on test flying, including power plants, propellers, hydraulic, pneumatic and safety equipment. Qualifications: British of British parents; recognised engineering apprenticeship; experience in aeronautical inspection an advantage; O.N.C., appropriate City and Guilds Final Certificates, or equivalent qualification desirable. Salary £820 (age 30) to £974 p.a.—Application forms from Ministry of Labour and National Service, 20, Nelson Street, Bristol, 1, quoting order number PE.3396. E9365

PUBLIC APPOINTMENTS

ENGINEERS

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE

To lead or work as Members of teams engaged on Research, Design and Development of mechanical and electro-mechanical equipment of a unique and unorthodox nature. The work covers a wide field including laboratory instruments, design of special equipment and acceptance testing of associated equipment. Equipment designed entails use of special materials and requires unusual design techniques.

There will be one post at Engineer II level for a MECHANICAL/ELECTRO-MECHANICAL ENGINEFR having considerable Drawing Office experience associated with Service departments.

The appointments are at various levels depending on ability and experience. A recognised engineering apprenticeship is required with several years' experience of engineering design works and Corporate Membership of one of the Senior Engineering Institutions, or equivalent qualifications.

SALARY : Engineer I £1790–£2080.
Engineer II £1300–£1740.
Engineer III £815 (at age 25)–£1100 (at age 34 or over)–£1270.

Contributory Superannuation Scheme. A house or alternatively substantial assistance with house purchase will become available for married officers living beyond daily travelling distance.
Postcards for application forms to the Senior Recruitment Officer at above address. Please quote ref. 2099/25.

E9392

MECHANICAL ENGINEER

to be responsible to the Works Engineer for the supervision of mechanical workshops and mechanical inspection associated with the take-over of new plant in the

NUCLEAR POWER STATION AT CHAPELCROSS

Applicants must have served a recognised engineering apprenticeship and have corporate membership of an appropriate senior engineering institution, or equivalent. Wide experience in mechanical engineering covering knowledge of up-to-date engineering practice in a general engineering shop, or construction and maintenance of heavy mechanical plant (including turbines) in a large works is essential.

Salary between
£1300 and £1740
according to qualifications and experience.

Contributory Superannuation. Staff housing scheme.

Send postcard for application form, quoting reference 2795/JI to Works Secretary, UNITED KINGDOM ATOMIC ENERGY AUTHORITY, INDUSTRIAL GROUP, Chapelcross Works, Annan, Dumfriesshire, Scotland.

CLOSING DATE : 29th DECEMBER, 1958.

E9350

TENDERS

ELECTRICITY TRUST OF SOUTH AUSTRALIA

PORT AUGUSTA "B" POWER STATION

TURBO-ALTERNATOR PLANT

TENDERS are invited for the MANUFACTURE, DELIVERY, ERECTION, TESTING and SETTING to WORK of the following TURBO-ALTERNATOR PLANT for Port Augusta "B" Power Station :—

Unit	No. 4 machine
Capacity (M.C.R.)...	60 megawatts
Steam conditions ...	900 p.s.i., 900 deg. F.

Specifications are available at the Offices of the Design Engineer, Hindmarsh Buildings, Grenfell Street, Adelaide, and Preece, Cardew and Rider, Consulting Engineers, 8, 10 and 12, Queen Anne's Gate, Westminster, S.W.1, London.

The Tender has to be received by 2 p.m. on Tuesday, 3rd March, 1959. No Tender will necessarily be accepted. Tenders must be submitted in triplicate. Two copies to be lodged with The Chairman, Purchasing and Contracts Committee, Electricity Trust of South Australia, Kelvin Building, North Terrace, Adelaide, South Australia, by the closing date and time specified, and one copy to be lodged with Preece, Cardew and Rider, Consulting Engineers, 8, 10 and 12, Queen Anne's Gate, Westminster, S.W.1, London.

E9389

INDIA SUPPLY MISSION

DIESEL LOCOMOTIVE

TENDERS are invited by the India Supply Mission, 2536 Massachusetts Avenue, N.W., Washington 8 D.C., for the supply of one number 250 h.p. DIESEL LOCOMOTIVE required for Neyveli Lignite Project in India. Tender forms containing instructions to tenderers conditions of contract specifications and offer forms priced 82.00 (14s. 3d.) per set can be obtained from the above office/ Director General India Stores Dept., Government Building, Bromyard Avenue, Acton, London, W.3, England ; Embassy of India, Naigai Building, 5th Floor, No. 13/20, Chome Marunouchi Chiyedoke, Tokyo, Japan ; Indian Trade Commissioner in Australia, Caltex House, 167-186, Kent Street, Sydney, Australia ; Director General of Supplies and Disposals, Shahajahan Road, New Delhi, India —quote reference Tender No. SE-24. Tender closing date January 6th, 1959. E9390

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.M.I., A.F.R.Ae.S., C.& G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29, WRIGHT'S LANE, LONDON, W.8.
E102

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A SENIOR ENGINEER, aged about 30–35, with several years' experience of the aerodynamic design and testing of compressors and turbines, required for the Power Jets' Consultancy Department at Farnborough, Hants. A responsible position covering a wide field of interest is offered. Good salary and superannuation. Excellent working conditions.—Fullest details in confidence to the Secretary, POWER JETS (R. and D.), LTD., 25, Green Street, London, W.1. E9405

AN ASSISTANT MECHANICAL ENGINEER—28 to 32 years of age—is required for an oil refinery. His immediate duties will relate to inspection and preventive maintenance. Applicants should therefore have had experience of this work in chemical works or refineries. The commencing salary will depend upon experience and qualifications. The position offers excellent future prospects, but candidates must be University Graduates and Corporate Members of a professional Institution.—Applications should be addressed to the Refinery Manager, Lobitos Oilfields, Limited, Ellesmere Port, Cheshire. E9356

SITUATIONS VACANT

ALFRED HOLT AND CO. THE BLUE FUNNEL LINE

Invite applications for the position of SUPERINTENDENT ENGINEER
New Construction

The successful candidate will assume responsibility under the Chief Superintendent Engineer for the engineering aspects of ships building and projected including calculations, specifications, layout, building progress and trials.

Candidates must have considerable previous marine engineering experience and qualifications equivalent to an Honours Degree in Mechanical Engineering, or an extra First Class M.O.T. Certificate. Applicants between the ages of 30–38 will be preferred. The appointment is at the Company's Head Office in Liverpool, and residence in that area will be necessary.

Applications, which will be treated in confidence, should be accompanied by two names for reference purposes. Suitable candidates will be asked to attend a preliminary interview at Liverpool when times and conditions of employment will be discussed.

Applications should be addressed to ALFRED HOLT AND CO., INDIA BUILDINGS, LIVERPOOL, 2, marked "Superintendent Engineer."

E9371

APPLICATIONS ARE INVITED for posts as PROFESSIONAL ENGINEERS for technical and design work on nuclear propelled vessels at the works of Vickers-Armstrongs (Engineers), Ltd., Barrow-in-Furness and Southampton. Applicants should hold an Honours, Pass Degree or H.N.C. in Mechanical Engineering. Drawing-office experience and experience in marine engineering will be an advantage. Salary appropriate to the responsibility of the post is offered and there is a contributory pension and life assurance scheme. These vacancies are suitable for ambitious men and successful applicants would, as far as possible, be given the choice of working at Barrow-in-Furness or Southampton, but would have to be prepared to move their homes to which ever district they were allocated. Those coming to the main establishment at Barrow-in-Furness would find that the town is pleasantly situated on the coast, adjacent to the Lake District. The company has a well-appointed sports club and grounds, with comprehensive recreational facilities, both social and sporting, and, in addition, the town has quite a number of excellent societies which cater for practically all tastes. An illustrated guide to the town and surroundings can be sent on request.—All applications will be treated in confidence and should be addressed to The Manager, Marine Propulsion, Research and Development, Vickers-Armstrongs (Engineers), Ltd., Naval Construction Works, Barrow-in-Furness, Lancs. E9357

APPLICATIONS ARE INVITED FROM ENGINEERS for responsible posts on research and development of PRODUCTION PROCESSES for the engineering industry. Excellent opportunities for those with ability and initiative. Candidates should have an engineering degree, Higher National Certificate, or equivalent qualification. Excellent working conditions in pleasant surroundings. Superannuation scheme. Removal expenses paid.—Send full details including age, qualifications, experience and present salary in confidence to BOX No. E9308, "The Engineer."

APPLICATIONS ARE INVITED FROM PROJECT ENGINEERS over 28 years of age and having H.N.C. minimum qualification, for a vacancy in the Production Engineering and Development Department at Ferodo, Ltd. This is a senior staff appointment and candidates must have had experience in one or more of the following subjects : Production Engineering and Plant Layouts, Factory Mechanical Services Layouts, Special Plant Design. The successful candidate will be responsible for handling projects through initial investigation, preparation of estimates and reports, ordering plant and equipment and arranging for installation and final handing over to the Works.—Write, giving details of age, qualifications, previous experience and salary required, to the Personnel Manager, Ferodo, Ltd., Chapel-en-le-Frith, via Stockport. E9289

ASSISTANT PLANT INSPECTOR

BAHRAIN PETROLEUM COMPANY, LIMITED

APPLICATIONS are invited for this position from men with a Degree in Engineering, Metallurgy or Physics who have had a minimum of two years' experience in the design, construction, or maintenance of unfired pressure vessels, including a year on their inspection in service. Candidates should be familiar with A.P.I., A.S.M.E. codes applicable to Petroleum Liquids and Gases, since the duties include inspection and gauging on vessels, exchangers, pumps, lines, valves, &c., in those services.

The commencing salary is £1332 per annum, in addition to which free air-conditioned accommodation and a living allowance are provided. An initial kit allowance, medical attention, paid local and home leaves are also provided.—Apply in writing, with full particulars, to Caltex Services, Limited, Caltex House, Knightsbridge Green, London, S.W.1, quoting "INS."

E9397

BEECHAM OVERSEAS, LTD., have a vacancy for an EXECUTIVE ENGINEER in the Development section at their headquarters in West London. The successful applicant should have a recognised qualification in either mechanical, plant, production or chemical engineering. The position is an interesting and attractive one covering a wide field of technical development in connection with buildings, plant layout and plant installations relative to the production of medicinal, toilet and beverage products overseas. Applicants should be between the age group 25–35 and be prepared to increase their technical know edge by further study and if necessary by attending classes approved by the company.—Apply in writing only, giving full details of age, qualifications and experience to the Personnel Controller, Beecham Group, Ltd., Beecham House, Great West Road, Brentford, Middlesex. E9379

CHIEF DRAUGHTSMAN

Company manufacturing rolling mills and other steelworks machinery require first-class man. Only those with the necessary technical qualifications and experience in the control of a drawing-office need apply. Full details, including age, to be stated.—BOX No. E9336, "The Engineer."

COMMERCIAL ELECTRICAL ENGINEER required by Merchant Company for Malaya. Minimum qualification O.N.C. ; age up to 26 ; bachelor. Good salary, scale according to qualifications and experience, and excellent prospects. Annual increments ; Provident Fund ; Pension scheme ; free furnished accommodation ; passage provided.—Write, BOX No. 1822, c/o Abbotts, Eastcheap, London, E.C.3. E9373

DESIGN ENGINEER required by London firm of general mechanical engineers. A practical background and several years' experience of machine design essential. Knowledge of mechanical handling an advantage. H.N.C. or equivalent qualification preferred. Interesting, varied work, requiring initiative and responsibility. Starting salary not less than £1000 p.a. Pension scheme canteen.—BOX No. E9314, "The Engineer."

DESIGNER-DRAUGHTSMAN (MECHANICAL) required for research and development team engaged on interesting development work in connection with special structures and diesel and steam-operated plant. Minimum qualifications H.N.C. Age group 24–30 years. The appointment is permanent and progressive in an expanding organisation. Contributory pension scheme and good canteen facilities. Salary in accordance with age, qualifications and experience. The works are situated 15 (fifteen) minutes' bus journey from the centre of Ipswich.—Applications to Personnel Officer, THE BRITISH STEEL PILING CO., LTD., Claydon, Suffolk. E9335

DEVELOPMENT ENGINEER, as second-in-command to Manager, in charge of factory development. Work includes the construction and equipping of large new factories or extensions to existing factories, which is carried out in conjunction with architects, specialist engineers and production management. Development of special-purpose machines and processes is also undertaken. Preferable qualifications are : B.Sc. (Engineering) or A.M.I.Mech.E. ; experience in similar work ; knowledge of meat products industry. Age 30/40 years. The appointment will be located in West London. Walls is an expanding company within the Unilever organisation. Starting salary in the region of £1200 p.a. in accordance with age and qualifications ; comprehensive superannuation and sickness benefit schemes.—Applications, quoting ref. No. 176, should be addressed to Company Personnel Manager, T. Wall and Sons (Meat and Handy Foods), Ltd., Atlas Road, Willesden, London, N.W.10. E9361

DRAUGHTSMAN/DESIGNER, aged 35/40, with experience in construction of timber water cooling towers and concrete bases, required for North of England. Good salary conditions and contributory pension scheme.—BOX No. E2207, "The Engineer."

ENGINEER graduate for Project and Development work required. The work involves the development of special machines and the planning and commissioning of complete projects. Salary £800–£1200 depending on experience, preferred age bracket 25–35. A flat is available.—Apply, giving full details to The Chief Engineer, MICHAEL NAIRN & CO., LTD., Kirkcaldy, Fife. E9394

ENGINEER (Non-resident) by Middlesex County Council for Percy House, Isleworth, Middlesex (large home for aged). Required to take charge of, and be responsible for, operation and maintenance of engineering installations, comprising Calloway and Cornish boilers, Calorifiers, steam-driven circulating pumps, steam meter, &c., and usual central heating and domestic hot and cold water systems, steam cooking equipment, electric passenger lifts, power, lighting and sundry other installations. Should be conversant with installations to above and experienced in maintenance of same. Salary £655–£715 p.a. 44 hour week. Established, pensionable, subject to medical assessment.—Apply, giving full particulars and three referees to Chief Welfare Officer, I, Queen Anne's Gate Buildings, Dartmouth Street, S.W.1. Canvassing disqualifies. E9281

ENGINEERING LABORATORY

ENGINEER required to take charge of the experimental section of our research and development department.

Desirable qualifications B.Sc. or H.N.C. with development experience and knowledge of instrumentation and have some supervisory experience.

Please give brief details of qualifications and career to date to :

PERSONNEL MANAGER,
SERCK, LIMITED,
WARWICK ROAD, GREET,
BIRMINGHAM, 11.

E9383

INSTRUMENT ENGINEERS COURTAULDS, LIMITED

ENGINEERING DIVISION,
COVENTRY

Applications are invited from INSTRUMENT ENGINEERS with plant experience and suitable technical qualifications to enable them to fit into positions at Engineering Headquarters, working on instrumentation schemes for a wide range of industrial processes.

Other vacancies are available in factories for the installation and maintenance of instrumentation equipment.

Applications will be welcomed from suitable qualified people who wish to make a career in automatic control engineering in its widest sense.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds, Ltd., 16, St. Martins-le-Grand, London, E.C.1, quoting reference number B.51.

E9358

Classified Advts. continued on page 122

SITUATIONS VACANT

ENGINEERING SALES REPRESENTATIVE required for Midlands area, preferably resident between Birmingham and Manchester. Qualifications A.M.I.Mech.E. or equivalent standard. Design experience of mechanical handling plant for coal, coke and quarried materials essential. Age 32–45 years. State salary required. SOUTHERN AREA REPRESENTATIVE also required, with similar qualifications. Resident London–Reading district.—Robert Cort & Son, Ltd., Reading (ref. WLR).
E2209 A

JOHN LAING AND SON, LIMITED, have vacancies in their N.W. London Offices for :—

1. DESIGN ENGINEERS, with at least three years' experience of reinforced concrete work.
2. DRAUGHTSMEN, with some experience of reinforced concrete detailing for varied and interesting work on civil and structural engineering projects.
3. MECHANICAL ENGINEER, with some experience of heating, ventilating and electrical services.
4. Experienced DRAUGHTSMEN, with good technical training and some practical experience to prepare schemes under direction for electrical services, lifts and water services. Some knowledge of heating and ventilating and the relationships between services and buildings an advantage.

Men with general experience and willing to give enthusiastic help to a department handling engineering services are required. Permanent and progressive positions, staff superannuation scheme, 5-day week, canteen and sports club facilities.

Apply, stating age, experience and qualifications, to :
Personnel Manager (ref. C.M.D.5), John Laing and Son, Limited, London, N.W.7.
E9370 A

LIGHT TO MEDIUM STEELWORK CONTRACTORS and Fabricators in South-West London have the following vacancies. BUYER, experienced steel man, preferably also some knowledge of non-ferrous materials and metal finishing. ESTIMATORS, DRAUGHTSMEN.—Please write, with details of experience and salary required, to BOX No. E2206, " The Engineer." A

MAINTENANCE ENGINEER (35–40), good electrical knowledge.—Mark Anthony and Sons, Ltd., Chalk Hill, Watford, Herts. E2219 A

MECHANICAL DRAUGHTSMAN—with good all-round experience and capable of making up own specifications required for senior position in Maintenance Dept. of large organisation at London Head Office. Some experience of refrigeration an advantage. Non-Contributory Pension Scheme.—Write, giving age and particulars of experience to BOX No. E9360, " The Engineer." A

MECHANICAL ENGINEERS required by old-established British Oil Company for service in their Oil Refinery in the East ; age 25 to 30 ; must have served full apprenticeship in heavy engineering and have H.N.C. (no exception can be made). Generous terms with cost of living allowance : home leave with passages paid both ways : kit allowance : medical attention : free furnished quarters : Pension Fund.—Please write with full details of age, apprenticeship, qualifications, training and experience to BOX TE.949 c/o 191, Gresham House, E.C.2.
E9391 A

NUCLEAR POWER
GRADUATE MECHANICAL ENGINEER
required for development work (London) area, connected with pressurised water nuclear reactor system components and other high-pressure plant.

Applicants should have served an apprenticeship and have some industrial experience in the field of high-pressure, steam-raising plant.

Please apply in writing, stating age, qualifications and experience, to Staff Manager,
FOSTER WHEELER, LTD.,
3, Ixworth Place,
London, S.W.3.
E9313 A

PLANNED MAINTENANCE ENGINEER

A large West Midlands Steelworks requires an ENGINEER in the age range of 25–30 years to operate and extend a planned maintenance system for all steelworks and auxiliary plant. This post is looked upon as providing essential training for further progress within the engineering department, and applications are sought from men of university graduate or H.N.C. standard in either mechanical or electrical engineering, who wish to make a career in steelworks engineering.

Pension scheme and free life assurance.

Applications should be made giving details of experience to date with salary expected to BOX No. E9294, " The Engineer."

POWER STATION SUPERINTENDENT required to take charge of small installation in Iran for a first period of 2–3 years. Powerhouse comprises two oil-fired water-tube boilers of 52,000 lbs. per hour evaporation with usual auxiliaries, evaporator plant and one turbine of 3200kW output. Generous salary plus free accommodation and travelling expenses.—Apply stating experience, qualifications, age, &c., to BOX No. E2216, " The Engineer." A

QUANTITY SURVEYOR required for service in Tehran as Assistant Superintendent of Technical Services for the National Iranian Oil Company supervising, estimating, quantity surveying and material supply sections of their office. Qualifications : University degree or equivalent and Associate Membership of the appropriate Institution together with experience as a Quantity Surveyor, with estimating, and must have worked in a recognised Quantity Surveyor's Office. Age 35–45, salary in accordance with qualifications, but not less than £2500 free of Income Tax and with accommodation. Two year tours. Prospects of continuous long-term appointment if satisfactory.—Write, giving fullest particulars to Staff Office, Rendel, Palmer and Tritton, Consulting Engineers, 125, Victoria Street, London, S.W.1. E9354 A

SENIOR DESIGN ENGINEER. A firm of Fan Engineers require a Senior Design Engineer to be responsible for the system design office. Applicants should be qualified Engineers, B.Sc.(Eng.) preferred, and should be capable of controlling a team of designers. The Company is actively concerned with important contracts throughout the country and the position offered is one which offers unlimited opportunity to an Engineer with initiative.—Apply with details to Works Director, BOX No. E9385, " The Engineer." A

SENIOR DRAUGHTSMEN with specialised knowledge of layout and detail of air conditioning and allied plants. Technical education to Higher National Certificate or equal, capable of becoming section leader.—Write full details, " J " AIR CONTROL INSTALLATIONS, LTD., Ruislip, Middlesex. E9352 A

SENIOR ENGINEER required for research into the performance and utilisation of machine tools. Experience or knowledge of work study and production cost analysis would be advantageous. Work involves the acquisition of synthetic data and its application to economic studies of production operations, including numerically controlled machining. Excellent working conditions in pleasant surroundings. Pension scheme. Removal expenses paid. Send full details, including qualifications, experience and present salary, in confidence.—BOX No. E9321, " The Engineer." A

STEEL WORKS CRANES. An old-established crane manufacturer with head office and factory in the North of England seeks the services of a DESIGN DRAUGHTSMAN with sound experience of Overhead Electric Travelling Cranes to B.I.S.R.A. specification. This opportunity offers scope and unique prospects to a first-class man with initiative to whom a good salary will be paid.—Applications, which will be treated with absolute confidence, should give details of experience with age and salary required, and be addressed to The Managing Director, c/o BOX No. E2215, " The Engineer." A

TECHNICAL ASSISTANTS.—Applications are invited from young Engineers or Technicians to assist in the development of an industrial engineering division. Applicants should have experience in dealing with the technical problems of operational analysis and methods as applied to one or all of the following: Machine shops, fabricating and erection departments of a medium/heavy engineering industry. Qualifications H.N.C. (Mech.) minimum or equivalent. Age 25/35. Attractive and interesting appointments.—Applications in writing, with relevant details in confidence, stating approximate salary required, to Personnel Manager, Ruston-Bucyrus, Ltd., Excavator Works, Lincoln. E9244 A

THE UNITED GLASS BOTTLE MANUFACTURERS, LTD., ST. HELENS, LANCS.

To strengthen our Design and Development Department we are looking for young men who :
HAVE gained H.N.C. Mechanical Engineering or a higher qualification.
ARE keen to be DESIGN ENGINEERS
ARE capable of converting several years' experience in general engineering into specialised work.
HAVE a creative mind.
ARE ambitious but willing to learn.
HAVE the ability to get on with people.
ARE not afraid of hard work.
HAVE the strength of character to overcome difficulties.

Applications are invited from men who fulfil the above requirements and should be sent to the Personnel Officer.
E9386 A

TOP FLIGHT SALARIES OFFERED to accomplished TECHNICAL REPRESENTATIVES, preferably well qualified and with earlier experience in mechanical handling, by prosperous engineering company carrying out further expansion programme. Brief details in first instance, please, for local interview.—BOX No. E9366, " The Engineer." A

WORKS ENGINEER required by a well-established paper converting company in North-West London. Candidates should be between the ages of 30 and 40. They should have a sound practical experience of mechanical engineering and a good working knowledge of steam and electrical services. Salary will depend on experience and qualifications, but will be in the region of £1000 a year. Apply at first in writing, giving details of previous experience.—BOX No. E9263, " The Engineer." A

YOUNG ENGINEER, with knowledge of German, to install electro-pneumatic controls. Excellent opportunity for the right man. Must be mobile and capable of working on own initiative.—Replies, in confidence, stating age, experience and commencing salary required, to Managing Director, G. E. SIMM (ENGINEERING), LTD., 27, Broomgrove Road, Sheffield, 10. E9333 A

MASSEY-FERGUSON (GREAT BRITAIN) LIMITED

require a

CHIEF TRACTOR ENGINEER

Massey-Ferguson (Great Britain) Ltd., wish to appoint a CHIEF TRACTOR ENGINEER, who would be based at their Coventry establishment. The position calls for a Graduate Engineer or the equivalent who has had extensive experience in engines, transmissions and hydraulics and who will be responsible for the design and development of tractors.

The salary will be commensurate with the responsibilities of this important post and applications, giving full details of experience and qualifications, should be addressed in strict confidence to the Chief Personnel Officer, Massey-Ferguson (Great Britain) Ltd., Coventry.
E9355 A

SENIOR PROJECT ENGINEERS AND PROJECT ENGINEERS

BRITISH OXYGEN ENGINEERING LIMITED

Applications are invited from qualified and experienced engineers for posts as SENIOR PROJECT ENGINEERS and PROJECT ENGINEERS, entailing responsibility for the planning and co-ordination of the design, manufacture and site construction of large scale chemical plant and other engineering projects, including mechanical, electrical and civil engineering phases. Previous experience in this field and organising and administration ability is required.

Excellent salaries and conditions of service are offered and assistance with house purchase and removal expenses can be offered to successful candidates who will need to move their homes.

Applications should be made in writing to:—

The Personnel Manager (GH/26)
BRITISH OXYGEN ENGINEERING LTD.,
Angel Road, Edmonton, London, N.18.

E9368 A

PIPING DESIGNER/ DRAUGHTSMEN

A few vacancies exist for senior piping designers. Top positions are available with us in this field, but consideration will be given only to men who have considerable experience in piping design and layout of refinery and chemical plants or in related industries. Our Piping Designer/Draughtsmen are of a high standard and we therefore can consider only men of equal calibre. Our permanent staff benefit from above-average salaries, liberal personnel benefits, good working conditions, excellent Social Club, etc.

If you are interested and qualify you are invited to write to, or telephone the PERSONNEL MANAGER :—

KELLOGG **INTERNATIONAL CORPORATION**

7-10 CHANDOS STREET, LONDON, W.1. *Telephone : MUSeum 4010 quoting ref : 130/G*

E9384 A

GRADUATE MECHANICAL ENGINEERS

THOMAS HEDLEY & CO. LIMITED

LONDON MANCHESTER NEWCASTLE

Continuing Company growth has created several opportunities for young GRADUATE MECHANICAL ENGINEERS in the Technical Service and Maintenance Groups of our Factory Engineering Department.

The engineering work of the Company ranges from the development, design and construction of new buildings and equipment to the operation, maintenance and improvement of existing facilities.

The technical fields covered include fluid mixing and pumping, mechanical and pneumatic conveying, pressure and vacuum vessel design, heat transfer, automatic process control, high-speed automatic machinery and steam, power, air, gas, refrigeration and water supply.

While the opportunities available now are in the Factory Engineering Departments, every encouragement and opportunity is given to the young engineer to gain experience in all branches of our engineering work before finally selecting his career.

The Company is staffed by promotion from within. The new man is given individual training to prepare him for his first and succeeding assignments and throughout his career he is personally and individually coached by his immediate superior.

Starting salaries are attractive and increments are by merit. Removal and travel expenses and assistance with initial accommodation are provided by the Company, along with other benefits such as superannuation, free life assurance, etc.

If you have a good degree in mechanical engineering, are not more than 27 years of age and would like to know more about these appointments, we invite you to write, in confidence, including an outline of your qualifications and experience to :

The Chief Engineer,
THOMAS HEDLEY & CO., LTD.,
Gosforth,
Newcastle on Tyne.

E9372 A

SITUATIONS VACANT

THE DE HAVILLAND ENGINE COMPANY LIMITED

has a vacancy for an

ESTIMATOR/PLANNER

required for prototype and small batch quantities for development of industrial Gas Turbines and Air Compressors. Must have all-round practical experience. Interesting and responsible work.

Write, stating age and details of experience to :

The Personnel Officer,
THE DE HAVILLAND ENGINE COMPANY LIMITED,
Stag Lane, EDGWARE, Middlesex

E9399 A

SITUATIONS VACANT

GENERAL MANAGER

A Company, which is a subsidiary of a national contracting organisation, is seeking a GENERAL MANAGER to co-ordinate its activities over a large area in the North. The company specialises in heating, ventilating, electrical plumbing and industrial services and offers modern design facilities as well as up-to-date installation techniques.

The successful applicant will need to have first class contracting experience and a qualified or graduate Engineer would be preferred. Must be able to control all aspects of the business from enquiry to final settlement and above all weld the various specialists into a successful organisation. Good salary offered with Pension Scheme, car and excellent prospects.

Only applicants giving full personal details together with complete history of career to the present time will be considered and treated in strict confidence.—Write BOX No. E9403, "The Engineer."

A

SITUATIONS VACANT

PROCESS METHODS ENGINEERS

We have been requested by one of our clients—a well-known processor of non-ferrous metals and heavy chemicals—to secure Process Methods Engineers for the staff at one of their new plants located in the Midlands.

The appointments are of a permanent nature and promotion prospects are good. The Company already has an Industrial Engineering Department which is being expanded.

Candidates must be suitably qualified and have had good experience of methods engineering from a practical angle.

A commensurately suitable starting salary is offered and there is a good contributory Pension Scheme in existence.

Applications should be made in full to our Commercial Controller.

MEAD CARNEY AND COMPANY LIMITED
MANAGEMENT CONSULTANTS
43, PALL MALL, LONDON, S.W.1.

E9407 A

EXPERIENCED
CHIEF BLAST FURNACE ENGINEER
required

Must have experience with modern Furnaces, Power Generating Plant, Ore Handling Equipment, Sintering Plant, Gas Plants etc. Only first class Engineers at present earning £1,750 upwards need apply. House provided and a Pension Scheme in operation.

The MILLOM HEMATITE ORE & IRON Co., Ltd.
MILLOM, Cumberland.

E9388 A

LONDON TRANSPORT
have vacancies for
ENGINEERS

to design and execute the New Works Programme of railway capital projects and modernisation schemes.

Applicants should be capable of preparing schemes, contract drawings and specifications for some or all of the following :

Reinforced concrete bridges and structures.
Retaining walls, earthworks and drainage.
Heavy foundations. Steel bridges.

Applicants should be able to direct junior staff, have some experience of contract procedure and have a knowledge of estimating.

An engineering degree or membership of a professional institute is desirable.

Salary range : £1020 p.a.–£1185 p.a.

Medical examination, free travel, contributory superannuation scheme.

Applications stating age and qualifications and giving full details of experience should be sent within seven days to :

Staff and Welfare Officer (F/EV 717/4),
LONDON TRANSPORT EXECUTIVE,
55, Broadway, S.W.1.

E9398 A

SPERRY **GUIDANCE AND CONTROL SPECIALISTS**

Due to continued expansion of our Research and Development teams associated with "Seaslug" and the Long-Range Ballistic Missile, we have vacancies for experienced qualified personnel. The equipment dealt with is concerned with precision measurement, computation and instrument servo systems.

ELECTRONIC, ELECTRO-MECHANICAL and MECHANICAL ENGINEERS at Senior and Intermediate levels for design and development posts concerned with precision navigation equipments, components, and techniques on both the L.R.B.M. and "Seaslug" projects.

DIGITAL ENGINEER, to design and develop digital computors for airborne use, involving integrators, multipliers, storage units and equipment for remote adjustment and setting of digital quantities.

SYSTEMS ENGINEERS, to co-ordinate testing of a complete electro-mechanical precision instrument servo system, and to carry out design studies for, and the design of, more advanced systems.

MATHEMATICIANS or PHYSICISTS, for theoretical analysis of the performance of systems, design studies, and the analysis of flight trials data.

TEST FIXTURES ENGINEER, to direct Technical Assistants and D.O. personnel in designing and engineering a range of specialised complex electro-mechanical test fixtures.

TRIALS ENGINEERS, for the L.R.B.M., to accept full responsibility for testing and preparation for trials of important parts of the system. After training long periods away from base will be entailed, both in the U.K. and abroad, and salary and conditions of service will be appropriately attractive.

DEVELOPMENT ASSISTANTS, with H.N.C. or O.N.C., primarily for laboratory experimental work, with a certain amount of theoretical work on occasion.

TRIALS ASSISTANTS, for technical administrative and liaison duties.

PHOTOGRAPHER, for technical publications and handbooks, &c.

We are seeking professionally qualified, experienced personnel, and are prepared to reward them accordingly. Conditions of work will be first class in well-equipped new laboratories. Housing is available. Pension scheme, canteen.

Please write, giving full details or requesting application form, to R. W. H. Lubbock, B.Sc.

SPERRY GYROSCOPE CO., LTD.,
Bracknell, Berks.

E9387 A

THE BRITISH INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION

has a vacancy for a

PRINCIPAL RESEARCH ENGINEER (THERMODYNAMICS)

to lead research engineers engaged in investigations of combustion, pressure charging and fuel injection in diesel engines.

Candidates should possess an Honours Degree and have extensive experience of diesel engine research, including preferably some basic study of combustion.

Salary up to £2000 p.a., according to qualifications and experience. The post is pensionable.

Please apply in writing, giving age, education, training and experience, to :

The Director of Research, B.I.C.E.R.A., 111–112, Buckingham Avenue, Slough, Bucks.

E9380 A

SITUATIONS WANTED

TOP LEVEL EXECUTIVE ENGINEER (40), world travelled, wide experience all branches chemical engineering, seeks senior appointment sales promotion, contract liaison. Willing travel anywhere. Knowledge French, German, Russian. Tireless worker.—BOX No. E2214, "The Engineer." B

PUMP SALES : Executive seeks move to South West. Excellent background, 6 years in industry.—BOX No. E2217," The Engineer." B

EXECUTIVE ENGINEER, A.M.I.Mech.E. (45), seeks change. Wide experience on large projects in chemical, gasworks, steelworks and power station design. Conversant with civil and electrical problems and used to high-level negotiations and staff control. Successful career to date earns £2000 plus.—BOX No. E2221, "The Engineer." B

BUSINESSES and PREMISES

BOURNEMOUTH—LIGHT ENGINEERING BUSINESS, compact and easily managed by semi-retired engineer. Floor area approx. 1750 sq. ft.—centrally heated. Fully employed and many contracts in hand substantial companies. Some 20 modern machines. Price for new Lease, Valuable Equipment and Plant, Goodwill, &c. £6500 S.A.V. —Further details : Hudson & Son, 5, Yelverton Road, Bournemouth. Tel. : 6996. E9381 L

BUSINESSES and PREMISES

SCOTLAND—LANARKSHIRE

Glasgow 12 miles, Edinburgh 35 miles. Approximately five acres in all. Single storey buildings (45,000 square feet). Cranage facilities. Road and rail access. Sidings for up to 100 wagons. Fully equipped for timber wagon repairing. Good class of labour available. Propositions regarding the foregoing to :

RAMSAY, MENZIES & WILSON,
121, WEST GEORGE STREET,
GLASGOW C.2.

E9396 L

NON-FERROUS FOUNDRY AS GOING CONCERN, East London. Freehold. Approx. floor area 8500 sq. ft. Whole area approx. 2250 sq. yd. Well equipped. Capable 15 to 20 tons per month. Principals only.—BOX No. E2218, "The Engineer." L

FOR HIRE

LATTICE STEEL. Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. ('Phone SLOane 5259). E103 K

PATENTS

THE PROPRIETOR of British Patent No. 628,891, entitled "ROTARY CRUSHING MILL," offers same for Licence or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 14, E. Jackson Boulevard, Chicago, 4, Illinois, U.S.A. E9312 H

THE PROPRIETOR of British Patent No. 737771 entitled "A Machine for Operating on Strip Stock and a Reciprocating Slide Feed Therefor," offers same for license or otherwise to ensure its practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, Chrysler Building, New York 17, New York, U.S.A. E9378 H

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

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SUB-CONTRACTING

CAPACITY AVAILABLE FOR

DESIGN/DETAILING

OF

CHEMICAL, OIL & REFRIGERATION PLANTS
SPECIAL CONVEYORS & FACTORY MECHANISATION
STEEL & REINFORCED CONCRETE STRUCTURE
GENERAL PLANT & PIPE INSTALLATIONS
ELECTRICAL. POWER STATIONS, VEHICLES, ETC.
SUPERVISION OF MANUFACTURERS & INSTALLATIONS
ESTIMATING — PROCUREMENTS — TRACING
QUALIFIED ENGINEERS

Our representative will visit you upon request

RODGER, SETTERINGTON & PARTNERS
Hanger House, Western Avenue. Ealing W.5
PERivale 7877.
(Design Consultants — Mechanical. Civil & Electrical Engineers).

E9364 MW

MISCELLANEOUS

ENGINEERING CONSULTANTS

Our experienced staff can deal with your problems in any branch of engineering

Send your headaches to:—

EDGAR D. CANNON
60, BULLSMOOR LANE,
ENFIELD, MIDDX.
Tel.: Waltham Cross 5052

E2220 I

FOR SALE

VALES PLANT REGISTER LIMITED
OFFER FOR IMMEDIATE SALE

NEALS 1-ton " D " CRANE, 20–30ft., swan-neck Sectional Jib, ruston 1-VSH engine, on pneumatics, D100 series, new 1946, good condition. £750.
JONES Super 20 MOBILE CRANE, 24ft. jib, Lister diesel engine, on solids, G.W. order. £400.
NEALS " NM " 2-ton MOBILE CRANES, 20ft. jibs, Ruston engines, on pneumatics, new 1948–49, V.G. condition. £700 each.
VALES-REICH 3-ton 20/1300 electrically operated TRAVELLING CRANE. £2750.
JONES Super 40 3-ton MOBILE CRANE, 24ft. Channel Jib SC40680 series, on pneumatics, Turner diesel engine, generally overhauled and repainted. £975.
ANDERSON-GRICE 3-ton Electric DERRICK CRANE, 120ft. jib, S.L.I. " as new." £1600.
JONES, KL44 4-ton CRAWLER CRANE, 50ft. jib Ruston diesel engine, new 1950, overhauled. £1850.
BUTTERS 5-ton electric Single-Motor DERRICK CRANES, 105–110ft. Jibs, new 1948–49, good condition.
SMITH 5-ton Steam LOCO. CRANE, 4ft. 8½in. gauge, 35ft. jib, new mid. 1949, good order. £850.
COLES 6-ton Diesel/Electric MOBILE CRANE, 30ft. Cantilever jib, on pneumatics, new 1957.
BUTTERS & ANDERSON-GRICE 7-ton Electric DERRICK CRANES, 100–120ft. jibs from £1750 each.
ANDERSON-GRICE 10-ton Steam DERRICK CRANE, 120ft. jib, V.G. condition.
COLES 10-ton fully MOBILE CRANE, 30–40ft. jib, Perkins diesel engine, on pneumatics, new 1955, perfect condition. £5350.
COLES 12½-ton Fully MOBILE CRANE, 45–80ft. jib, new 1950. £5250.
FOR A COMPREHENSIVE LIST OF PLANT FOR SALE AND HIRE, SEND FOR VALES' FREE MONTHLY PLANT REGISTER.
Further details, 14, Lower Grosvenor Place, London, S.W.1. Telephone : VICtoria 7531, 3501, 8080, 9886 (15 lines). E107 G

FOR SALE

1 No. completely reconditioned and as new Fowler 150 h.p. 0-4-0 Diesel Locomotive for 4ft. 8½in. gauge.
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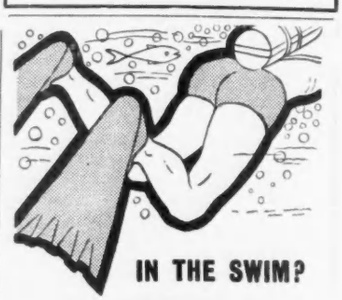

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SALES BY AUCTION

1958		*Main location*	*Auctioneers*
December 15-19	**Vehicles, machine tools and miscellaneous stores,** including textiles, etc.	M.O.S. Storage Depot, **Royal Arsenal, Woolwich, S.E.18**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
1959			
January 8	**Miscellaneous stores,** including :	General Stores Sub-Depot, **Longtown, Near Carlisle.** (Sale at County Hall, Carlisle.)	**HARRISON & HETHERINGTON, LTD.** (Dept.L), Botchergate, Carlisle. (Tel.: 26292.)
	Large quantity of wooden folding chairs and forms. Wooden and elevating trolleys. Canvas covers, valises, holdalls, water buckets and baths. Spike nails, screws, nuts, bolts, washers and rivets. Miscellaneous hand tools, including 14,000 hand saws, twist drills, spanners, 100,000 pick heads, taps and dies, camp kettles, metal cookers, Flit sprayers, smiths' portable forges ; sailmakers, packers and saddlers needles, cardboard cartons, etc.		
January 14	**Machine tools and miscellaneous stores**	Technical Stores Depot, **Old Dalby, Melton Mowbray, Leics.** (Sale at Melton Mowbray.)	**SHOULER & SON,** (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 3081.)
January 20-21	**Vehicles and miscellaneous stores**	Central Ordnance Depot, **Bicester, Oxon**	**MIDLAND MARTS, LTD.** (Dept. L), Market Square, Bicester, Oxon. (Tel.: 81.)

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Location : Landore, Swansea.
Tenders must be submitted by January 12.

APPLICATIONS (a) for catalogues for the auction sales should be made only to the auctioneers shown above (price of catalogues 1s. 0d., P.O. only).
(b) for Tender Forms, stating which tender is required, should be made to the Ministry of Supply, Directorate of Disposals, First Avenue House, High Holborn, W.C.1.

E118 J

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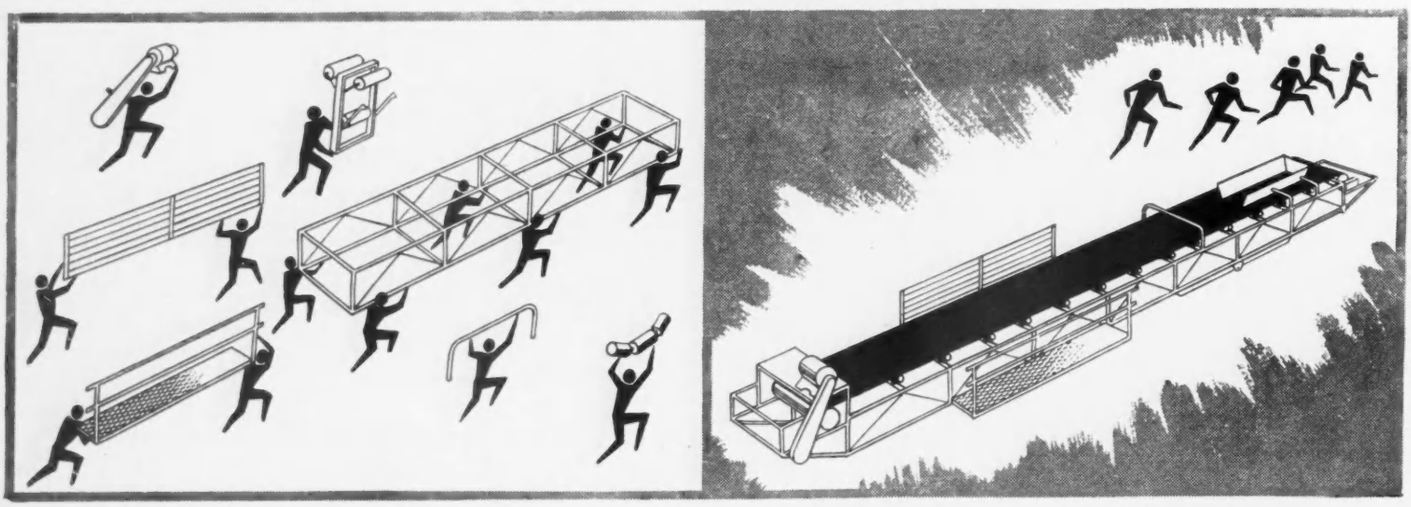

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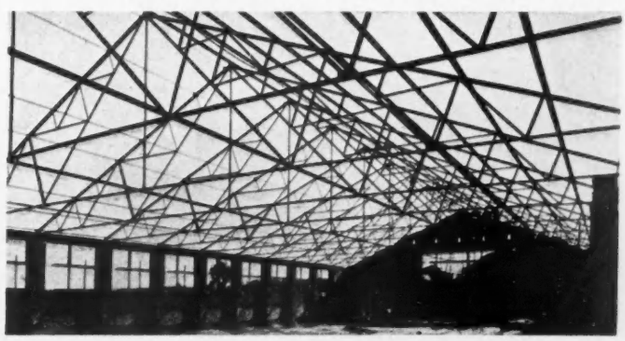

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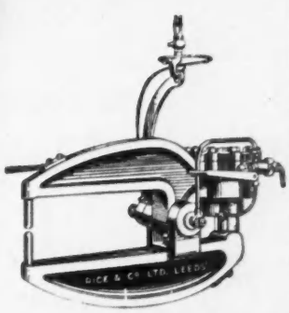

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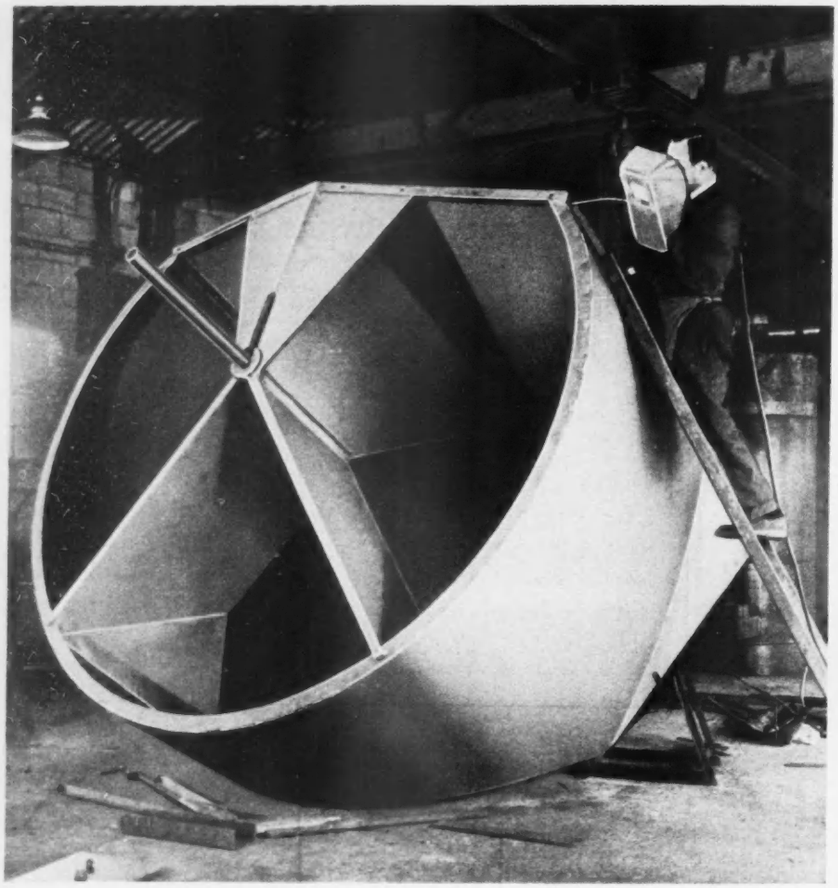

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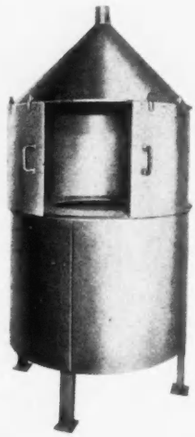

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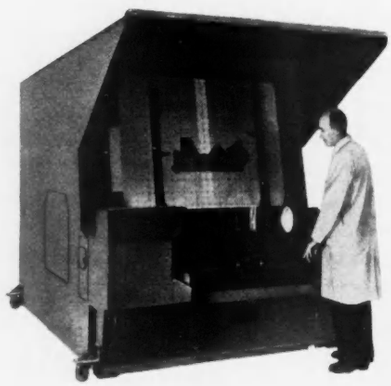

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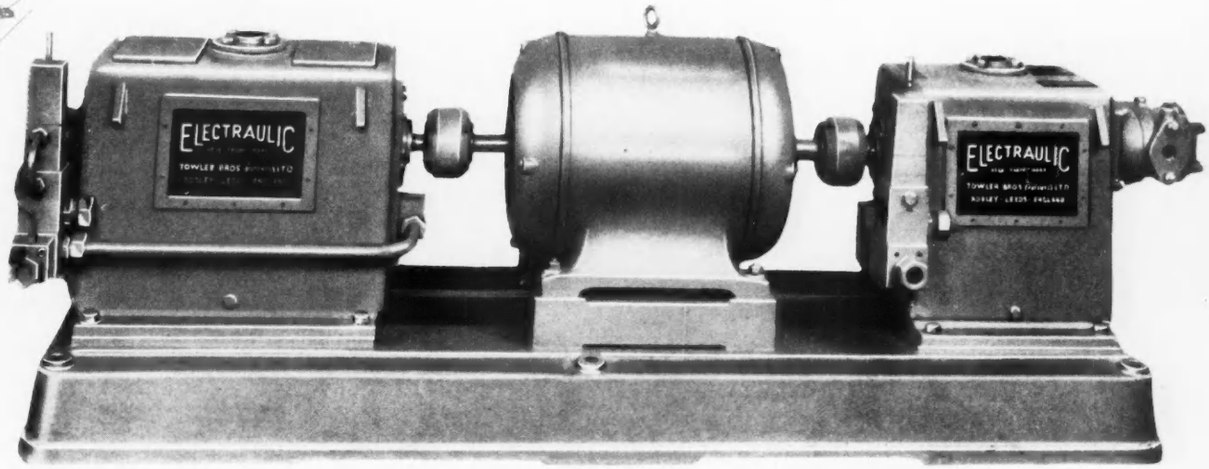

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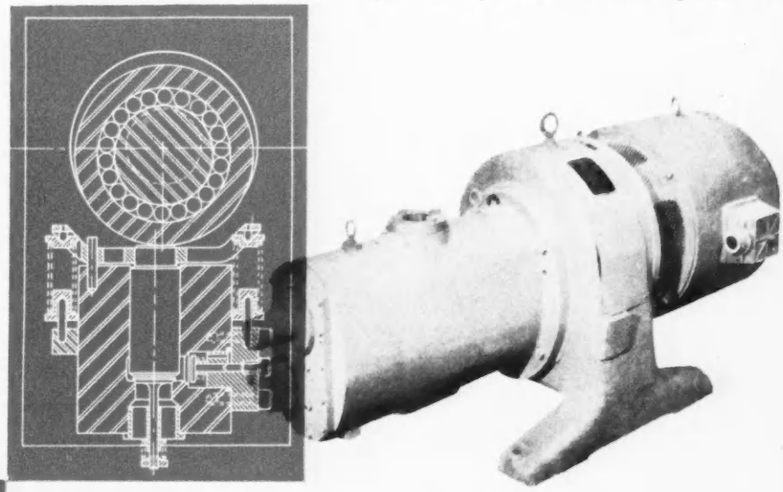

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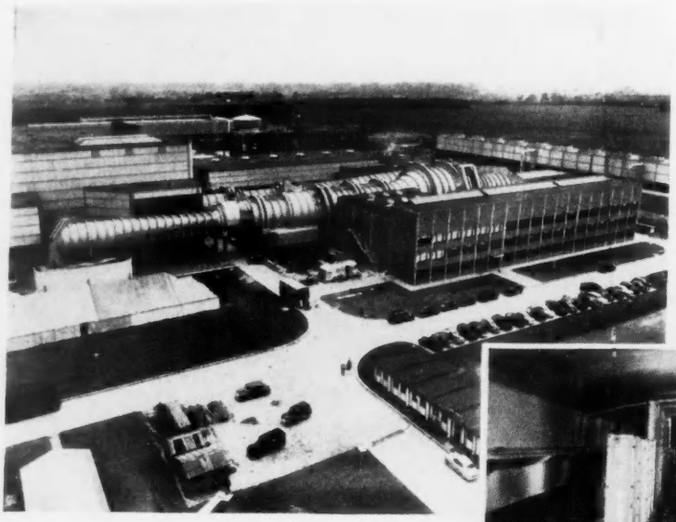

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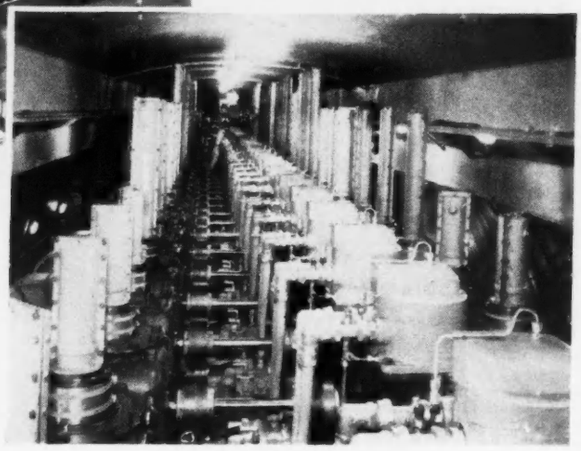

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